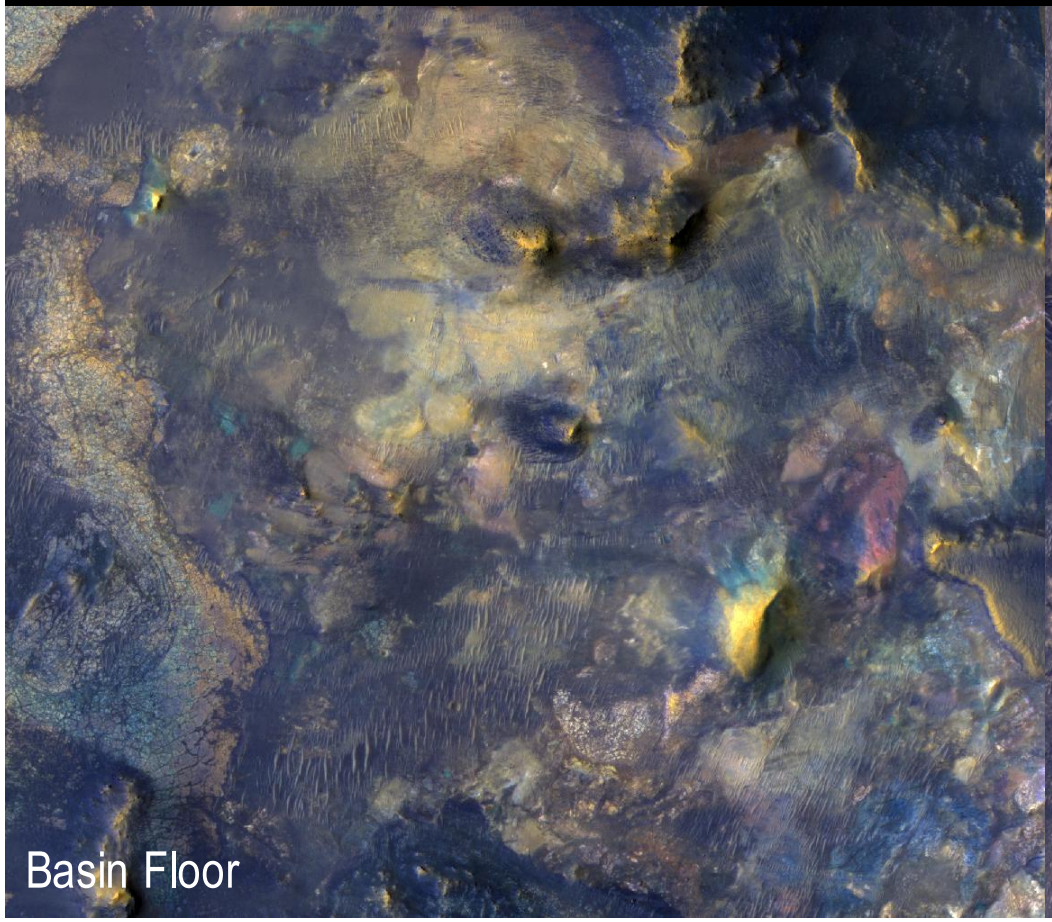
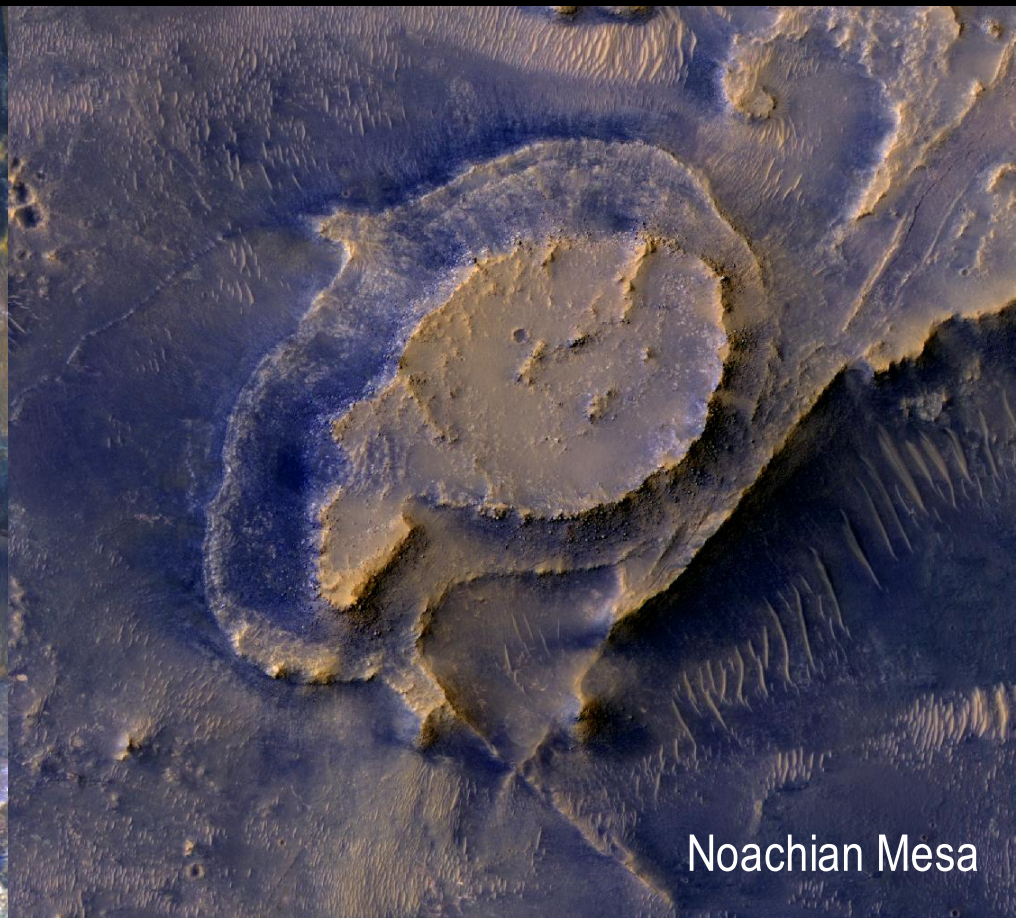
The Fluvial and Climatic History of Northeast Syrtis Major Mesas: Go-to Mission to Icy Mars

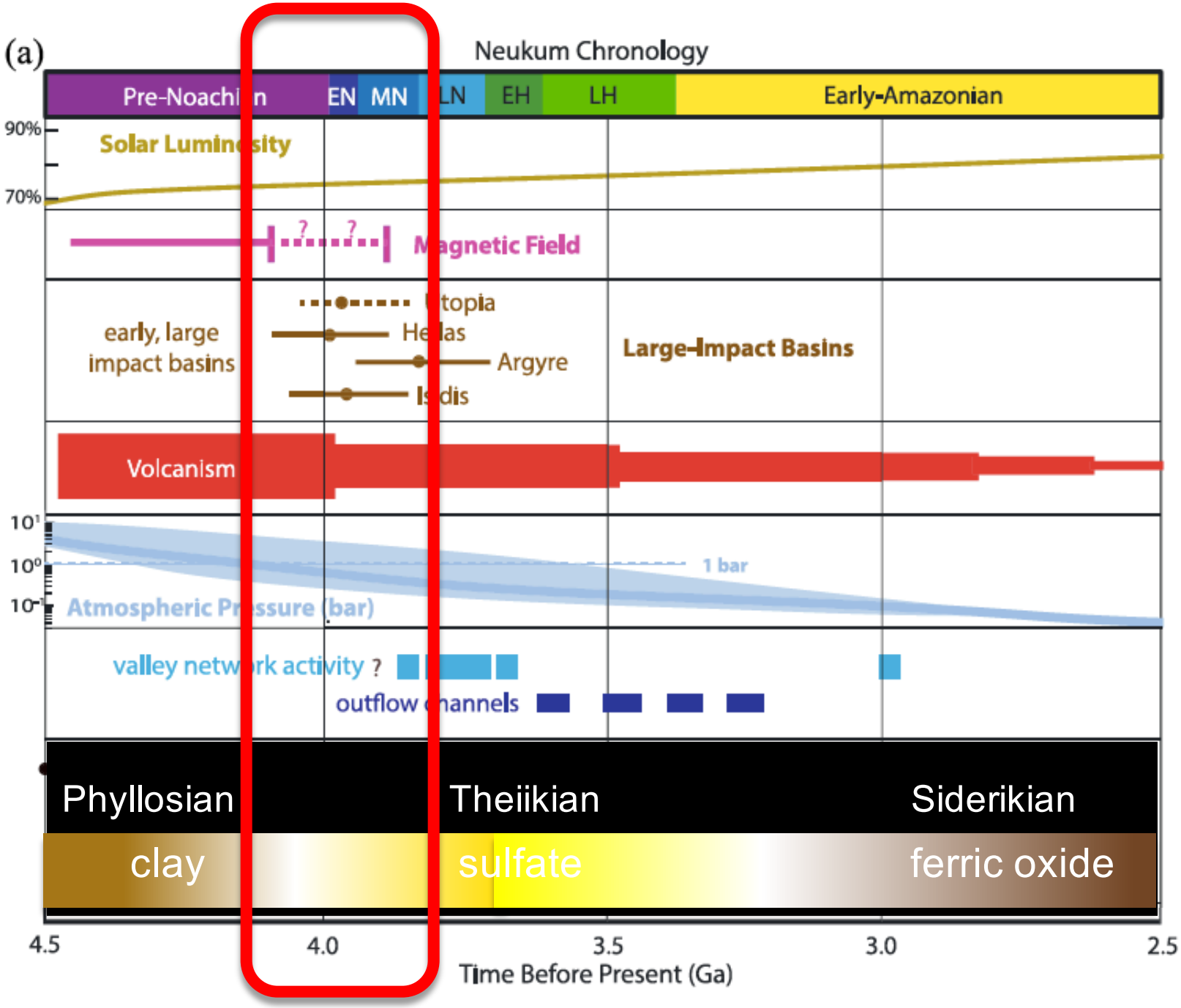
J.R. Skok and Jack Mustard

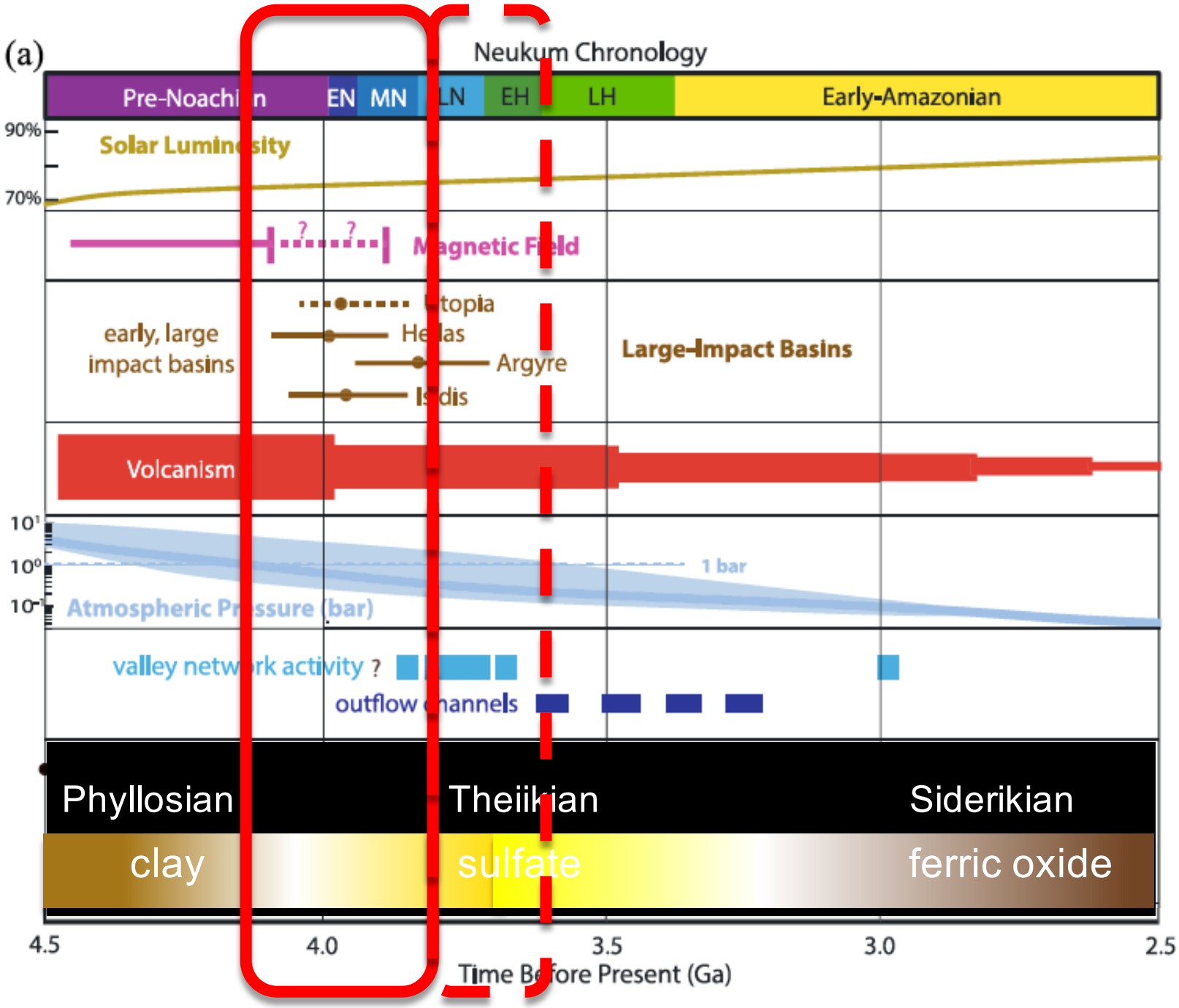
3rd Mars2020 Landing Site Workshop

February 9th, 2017






(a)
Neukum Chronology
Pre-Noachian
EN
MN
LN
EH
LH
Early-Amazonian
90%
70%
Solar Luminosity
?
?
Magnetic Field
Utopia
Hellas
Argyre
Isidis
early, large impact basins
Large-Impact Basins
Volcanism
10¹
10⁰
10⁻¹
1 bar
Atmospheric Pressure (bar)
valley network activity ?
outflow channels
Phyllosian
Theiikian
Siderikian
clay
sulfate
ferric oxide
4.5
4.0
3.5
3.0
2.5
Time Before Present (Ga)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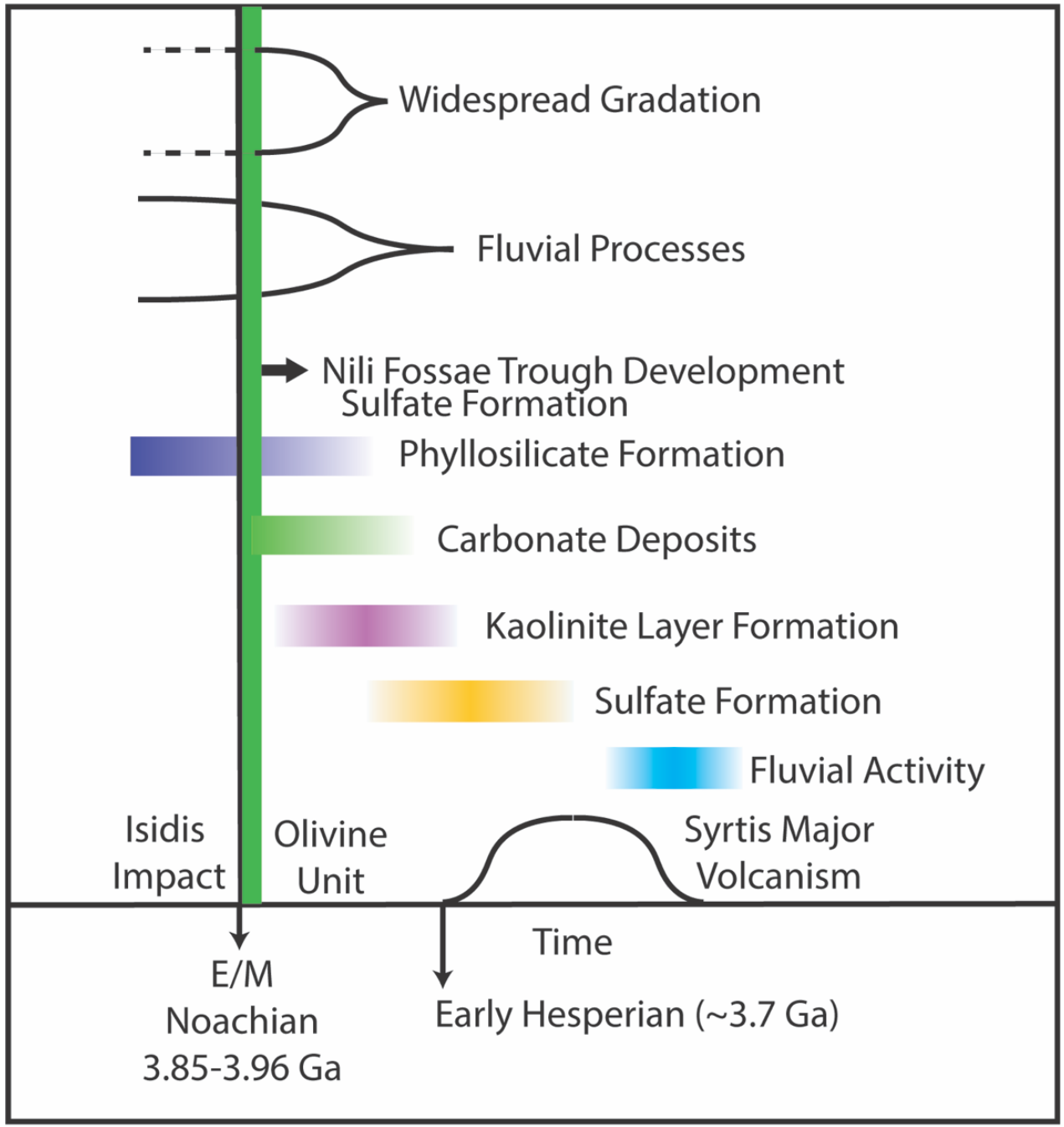
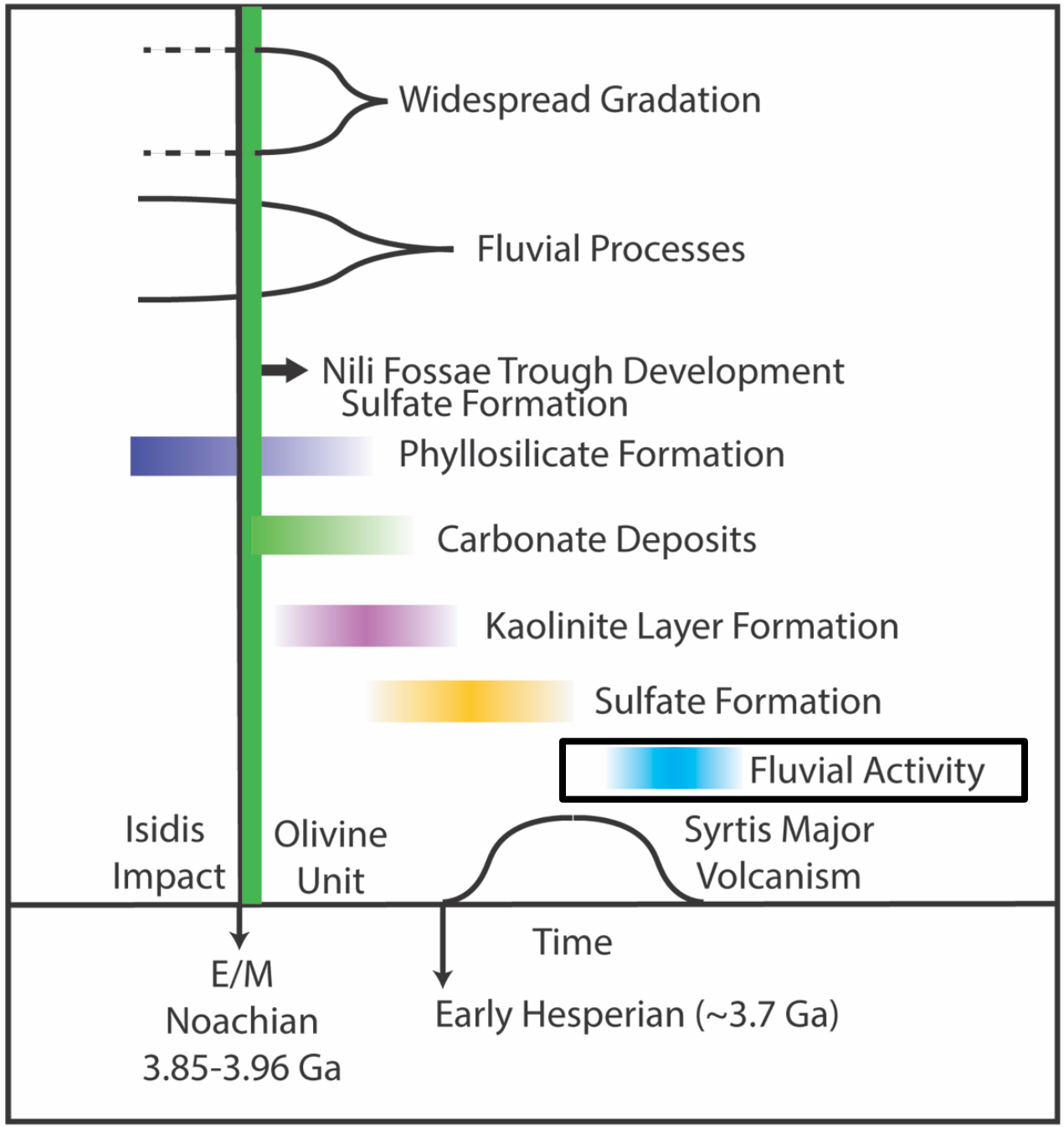
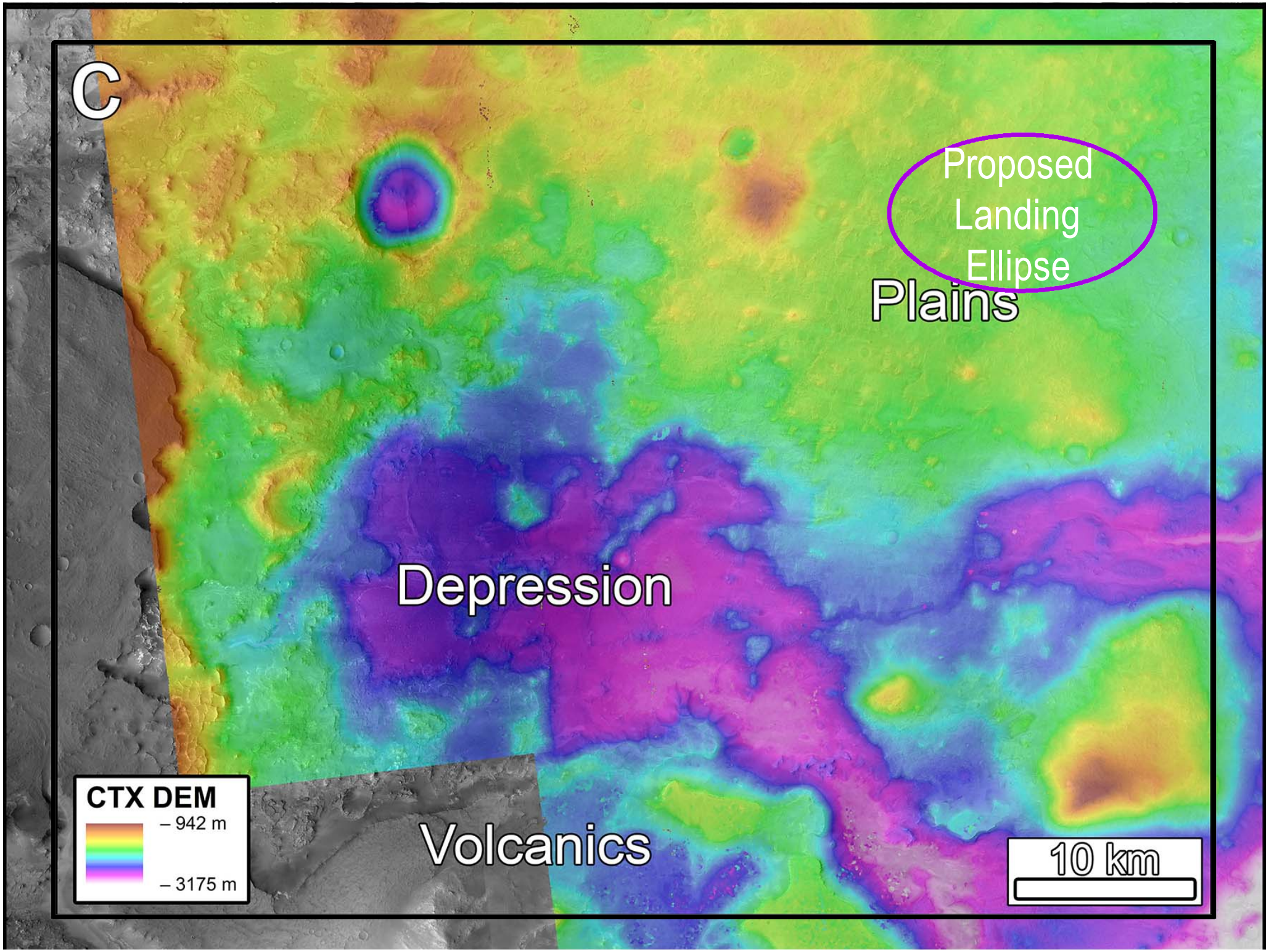
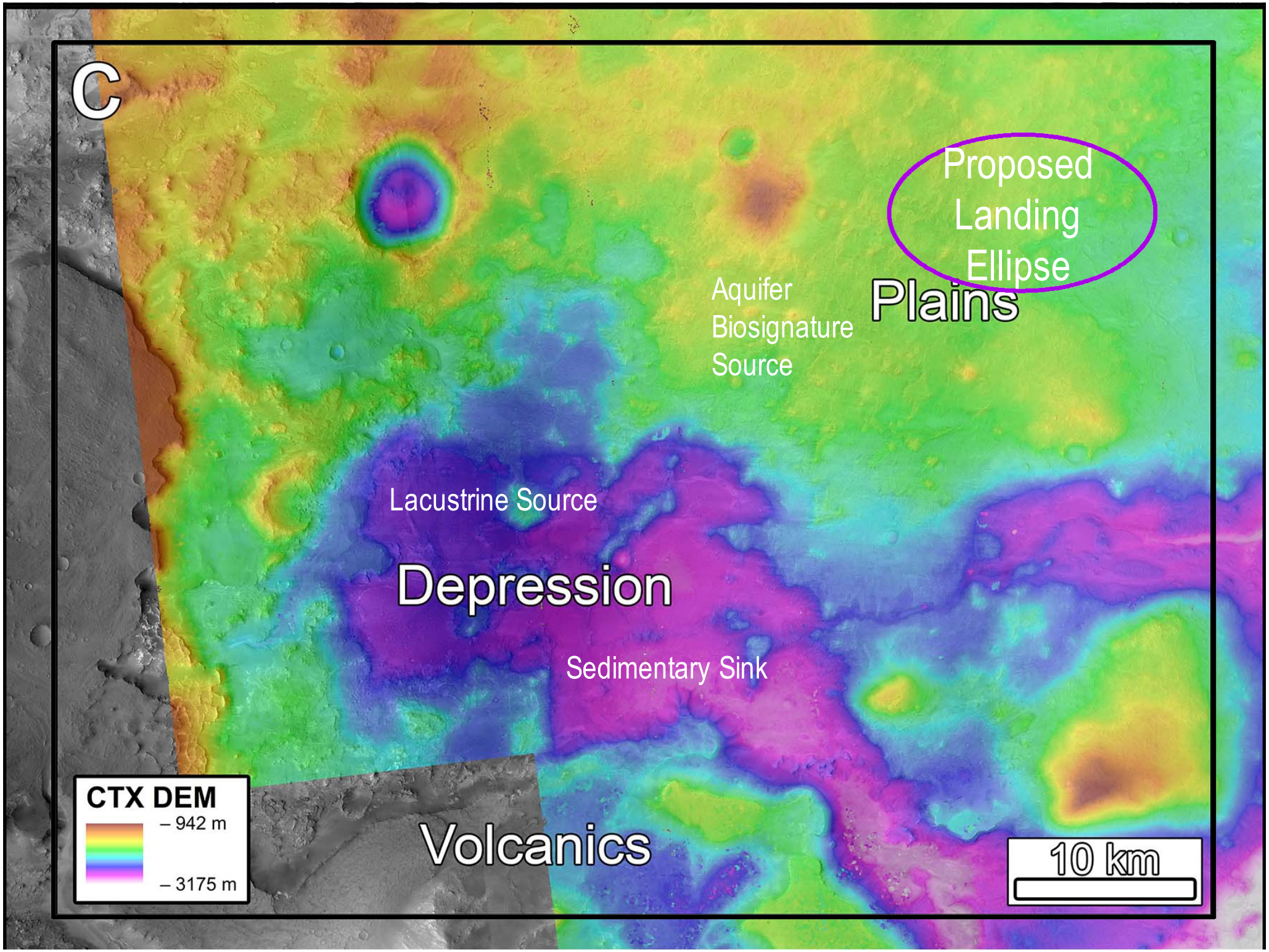
Northeast Syrtis Stratigraphy

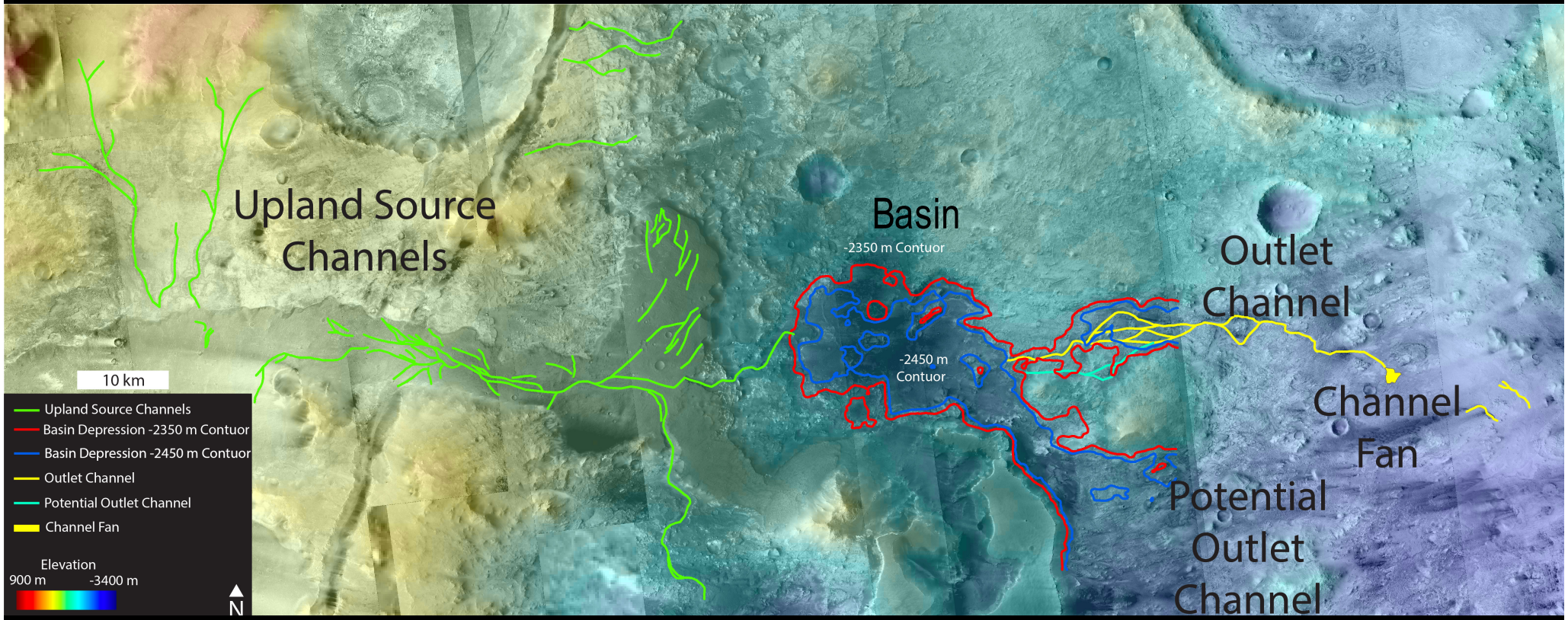


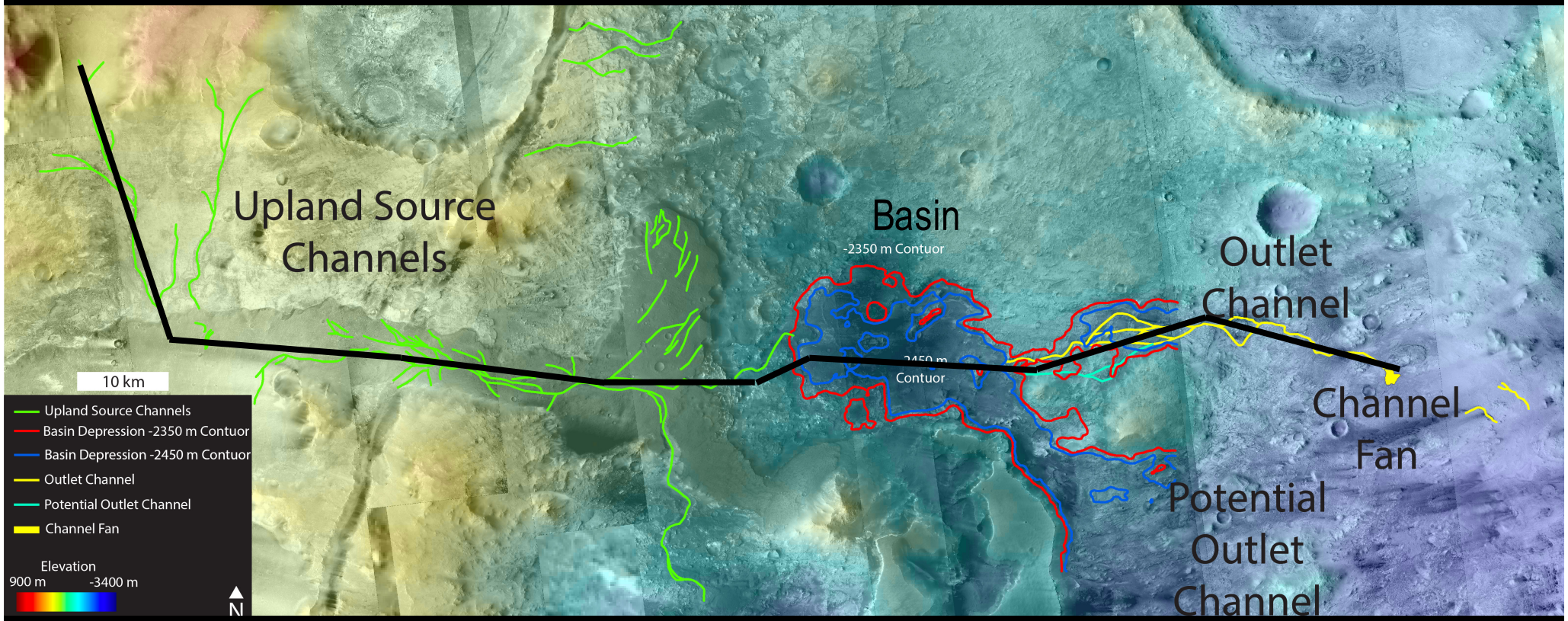
Northeast Syrtis Stratigraphy




C
Proposed
Landing
Ellipse
Plains
Depression
Volcanics
CTX DEM
– 942 m
– 3175 m
10 km


C
Proposed
Landing
Ellipse
Aquifer
Biosignature
Source
Plains
Lacustrine Source
Depression
Sedimentary Sink
CTX DEM
– 942 m
– 3175 m
Volcanics
10 km


Upland Source Channels
Basin
-2350 m Contuor
-2450 m Contuor
Outlet Channel
Channel Fan
Potential Outlet Channel
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N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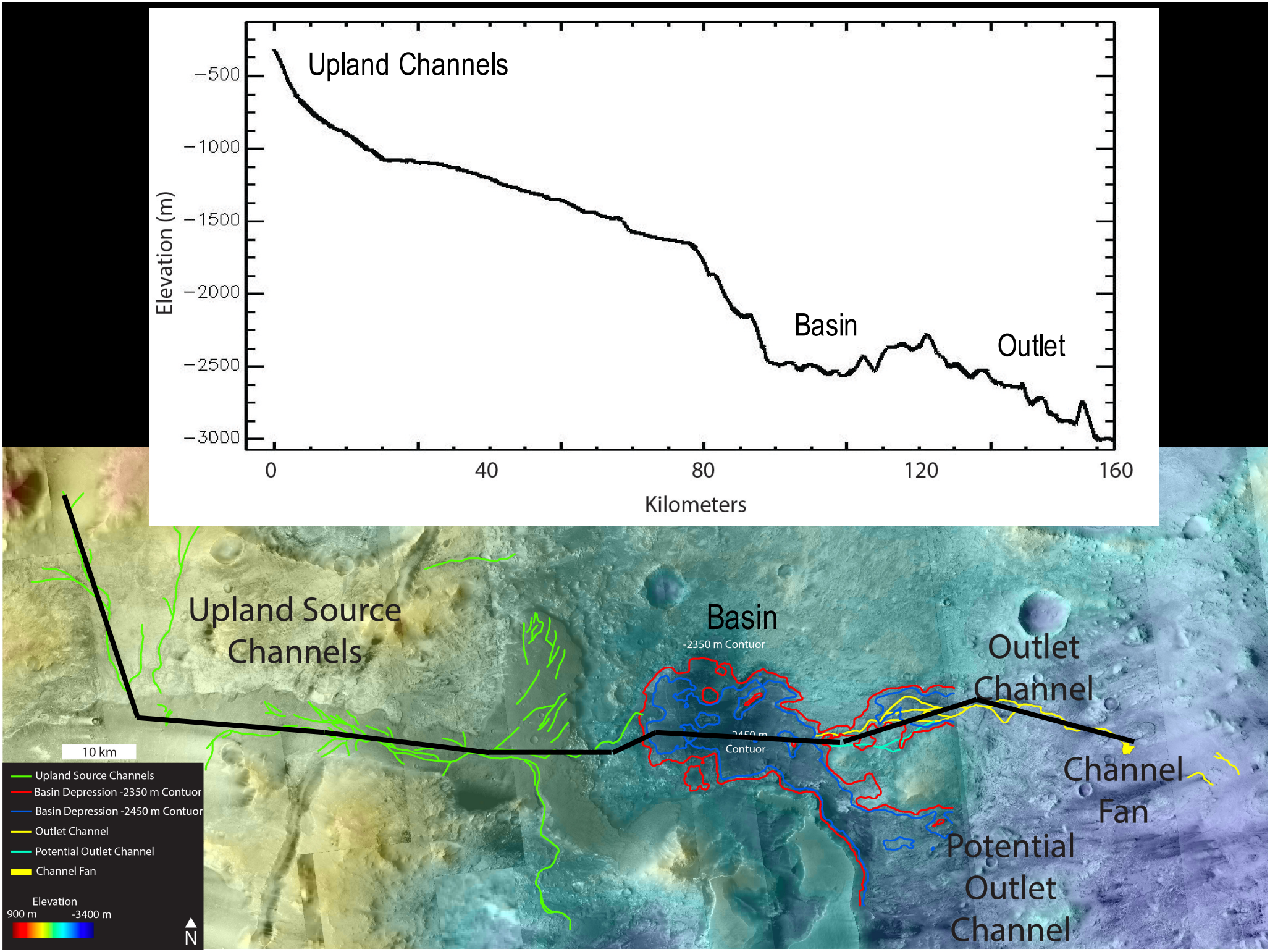
-2350 m Contuor
Outlet Channel
Contuor
Channel Fan
Potential Outlet Channel
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N


Upland Channels
−500
−1000
−1500
−2000
−2500
−3000
Elevation (m)
0
40
80
120
160
Kilometers
Basin
Outlet
Upland Source Channels
Basin
-2350 m Contuor
Outlet Channel
Contuor
Channel Fan
Potential Outlet Channel
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
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Elevation
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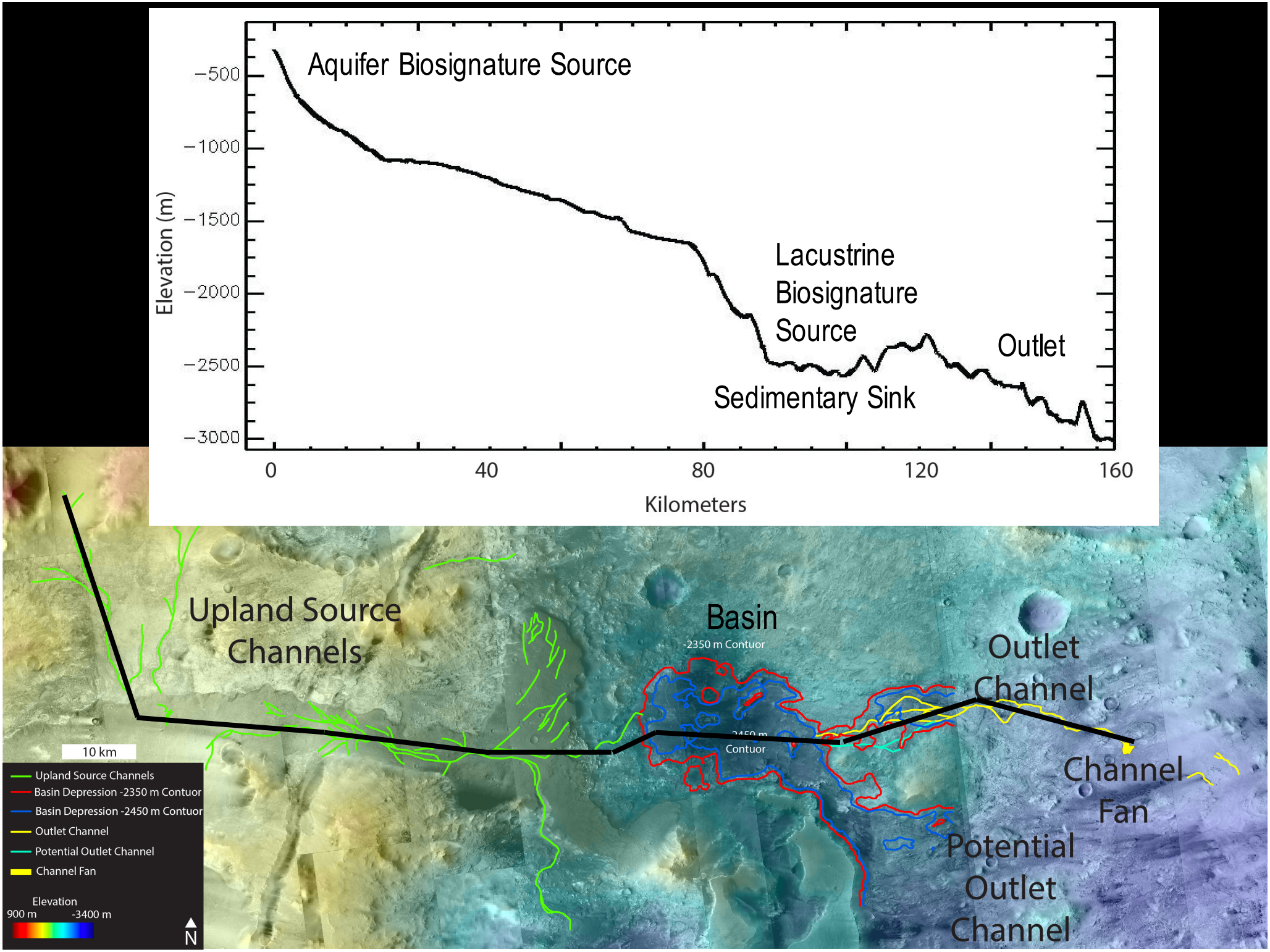
Aquifer Biosignature Source
Lacustrine Biosignature Source
Outlet
Sedimentary Sink
Elevation (m)
−500
−1000
−1500
−2000
−2500
−3000
0
40
80
120
160
Kilometers
Upland Source Channels
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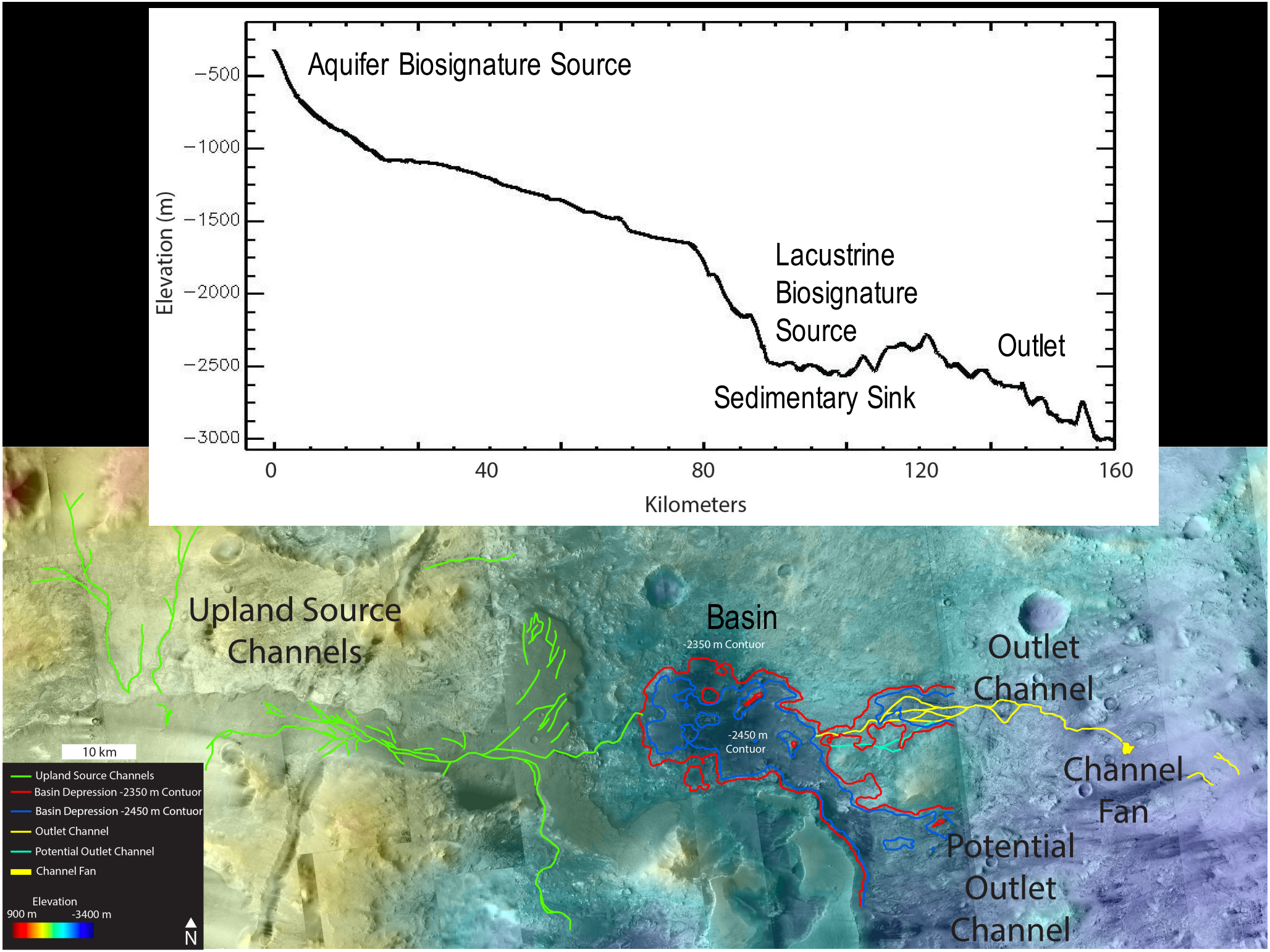
Aquifer Biosignature Source
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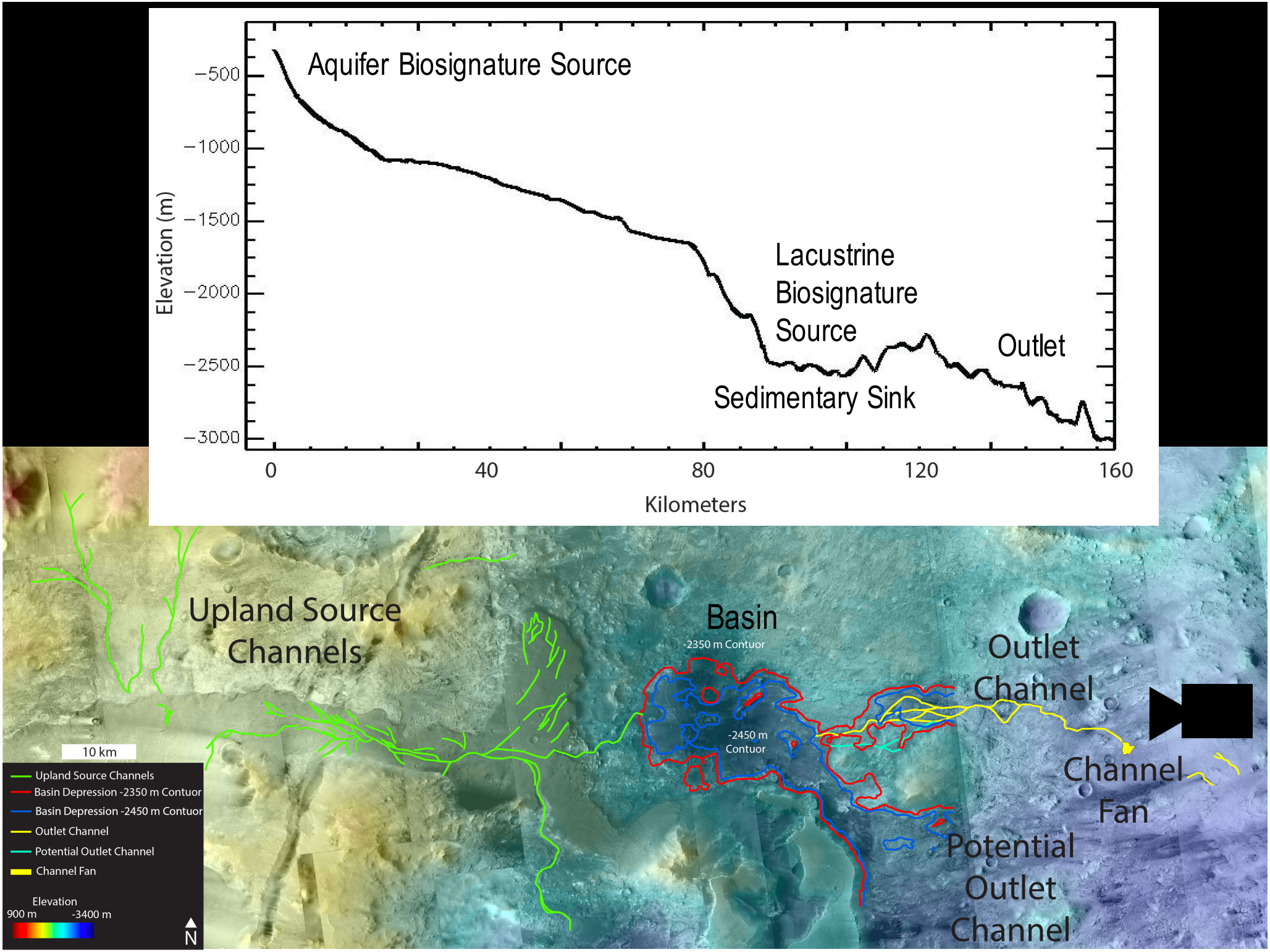
Aquifer Biosignature Source
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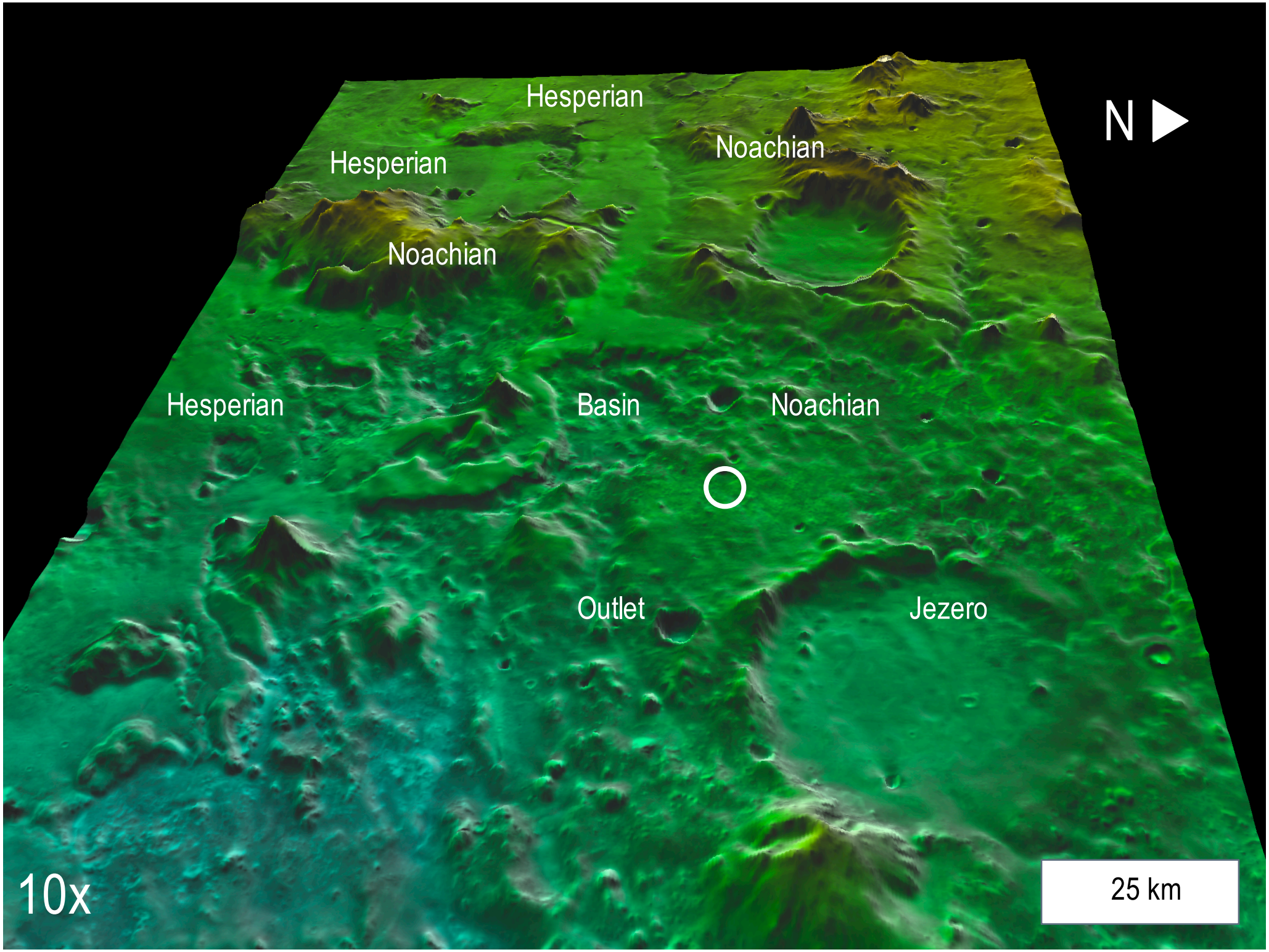
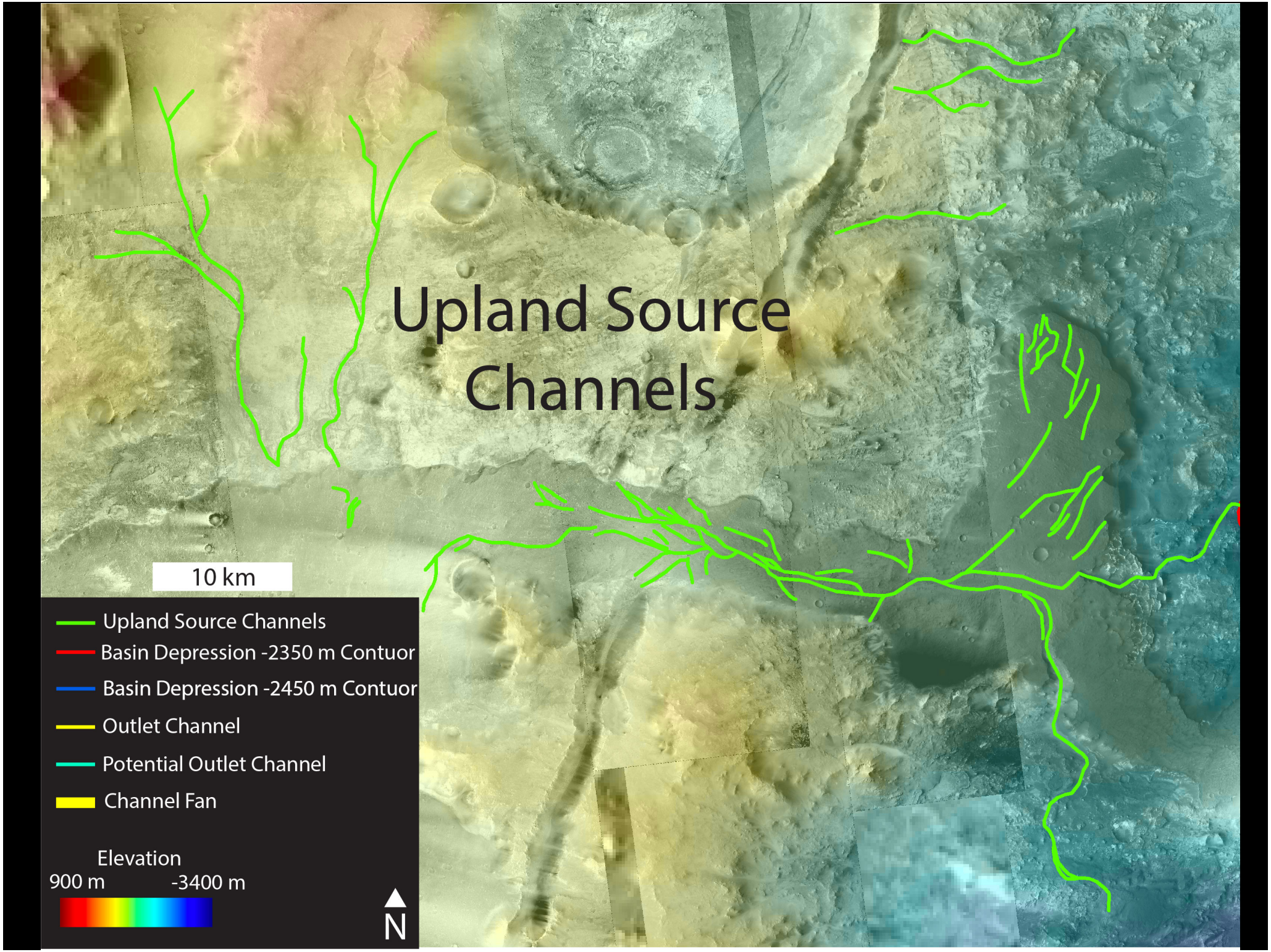
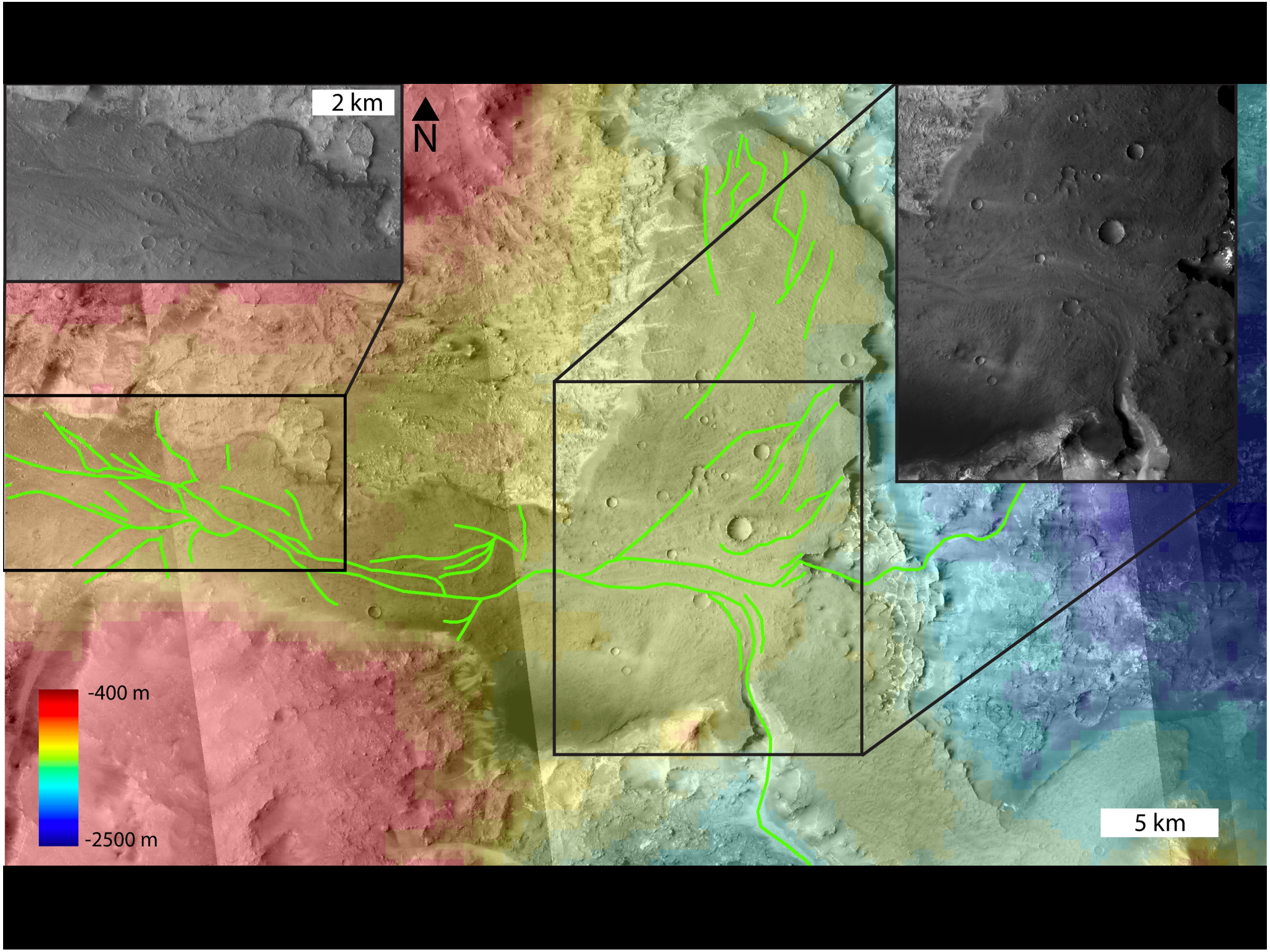
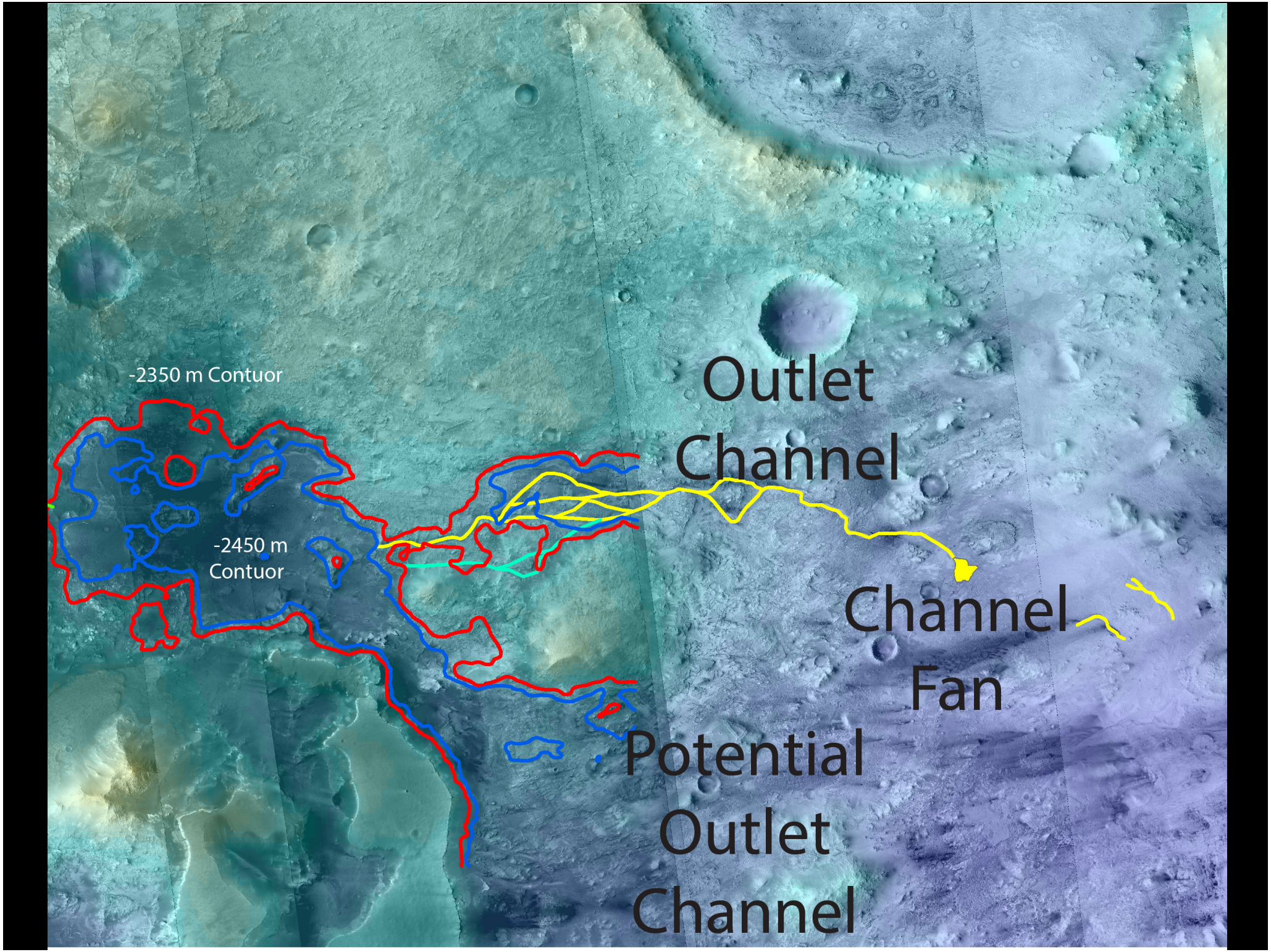
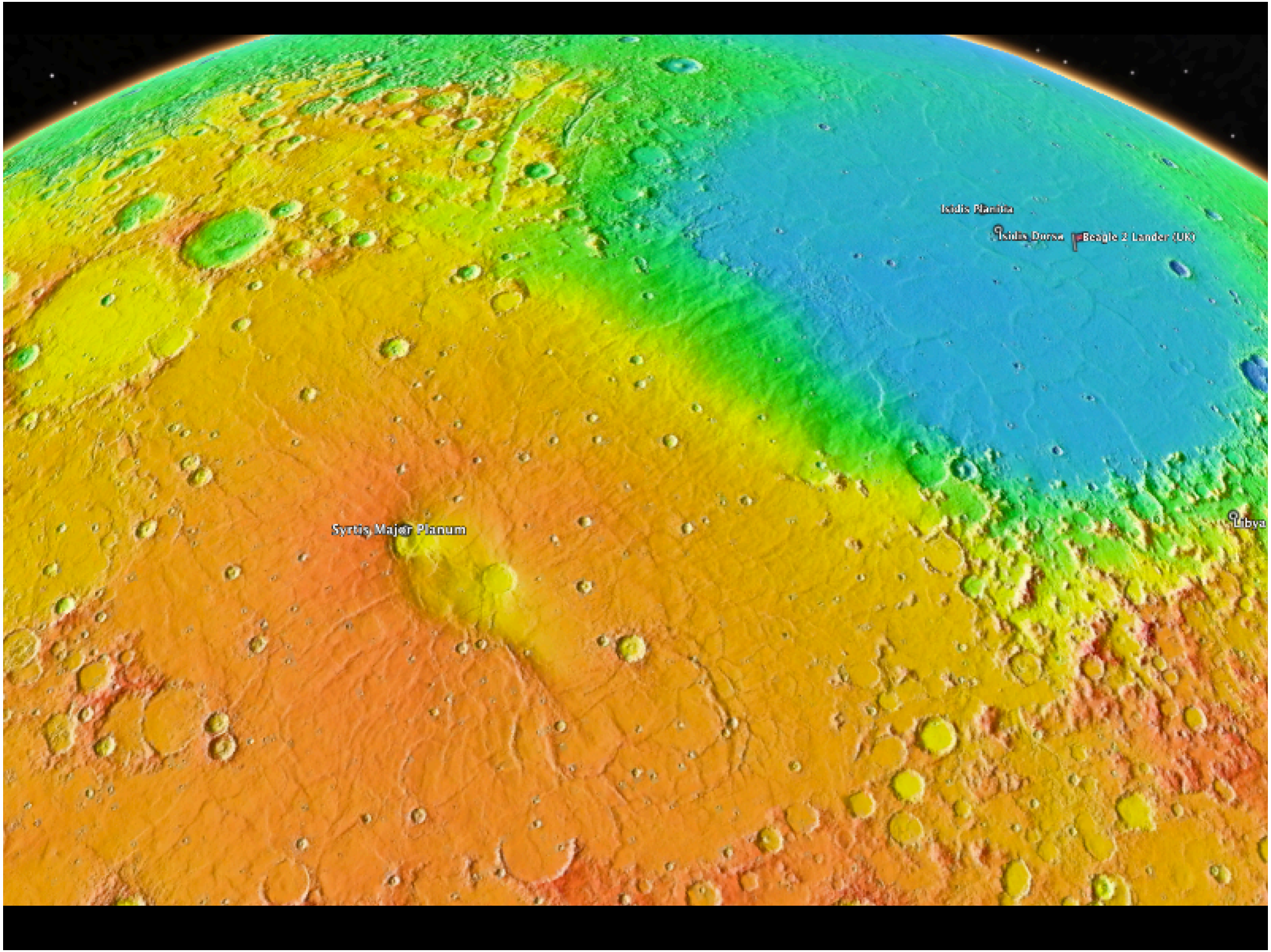
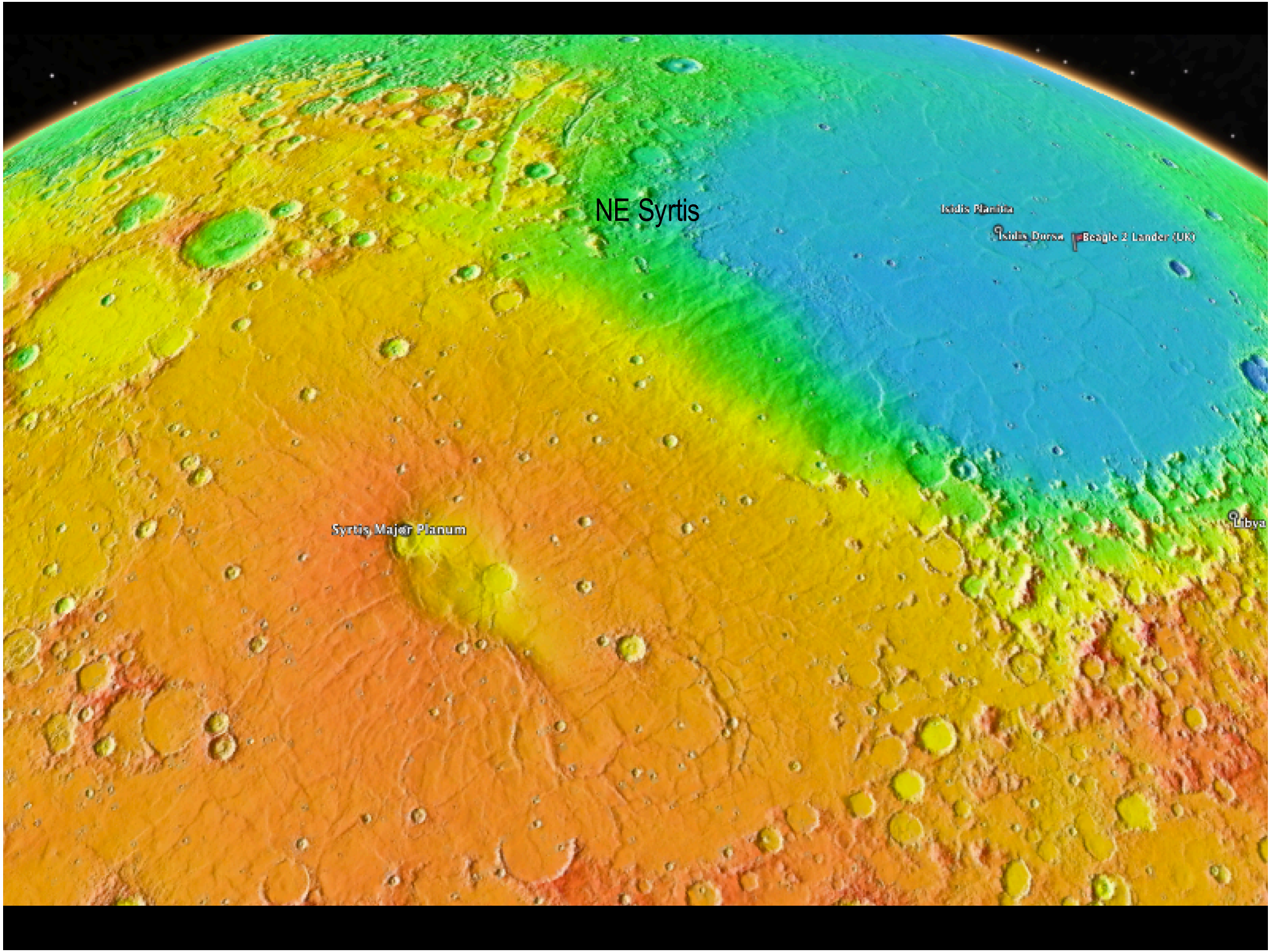

Hesperian
Hesperian
Noachian
Noachian
Hesperian
Basin
Noachian
Outlet
Jezero
N
10x
25 km

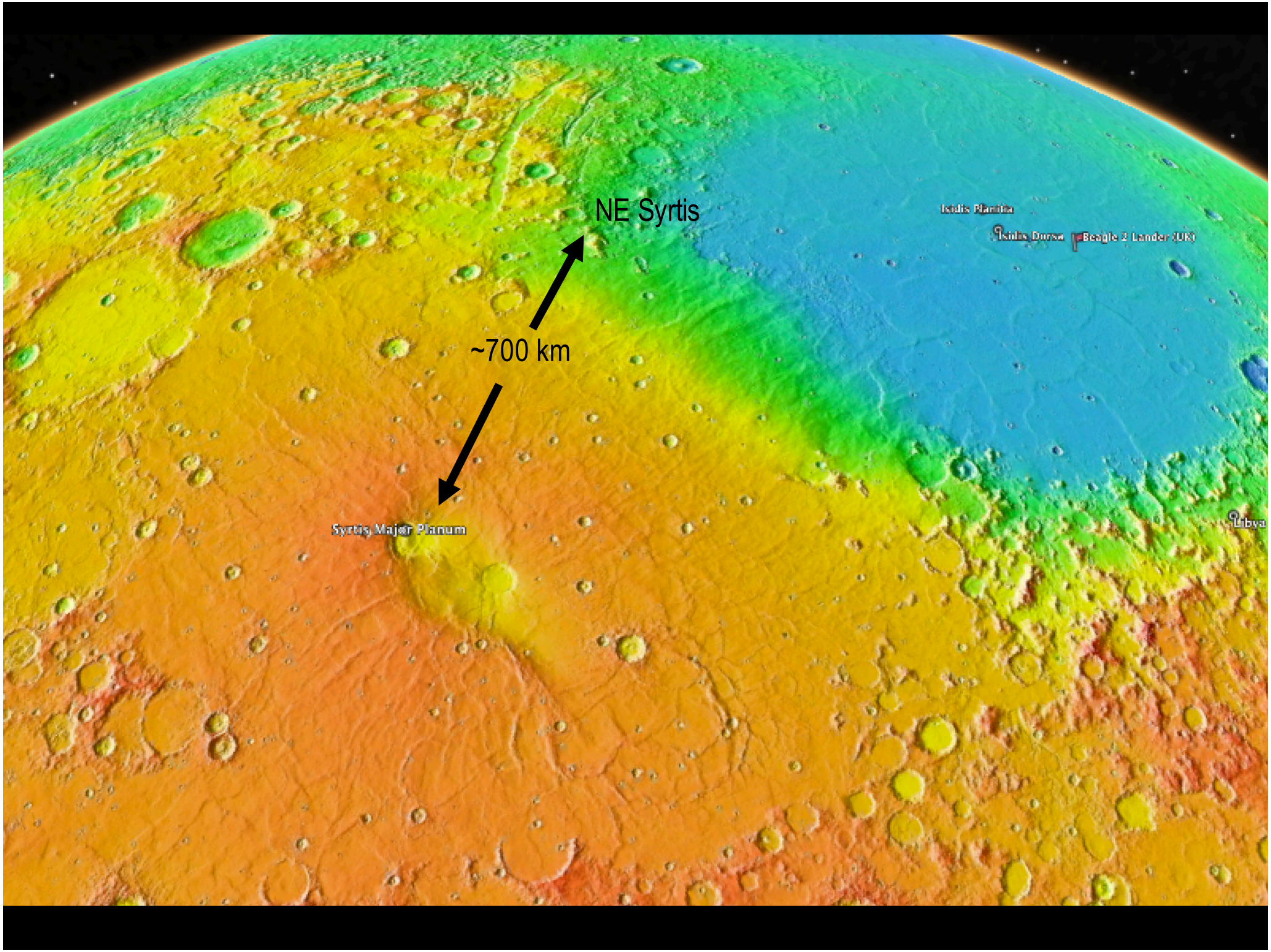

Upland Source Channels
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N

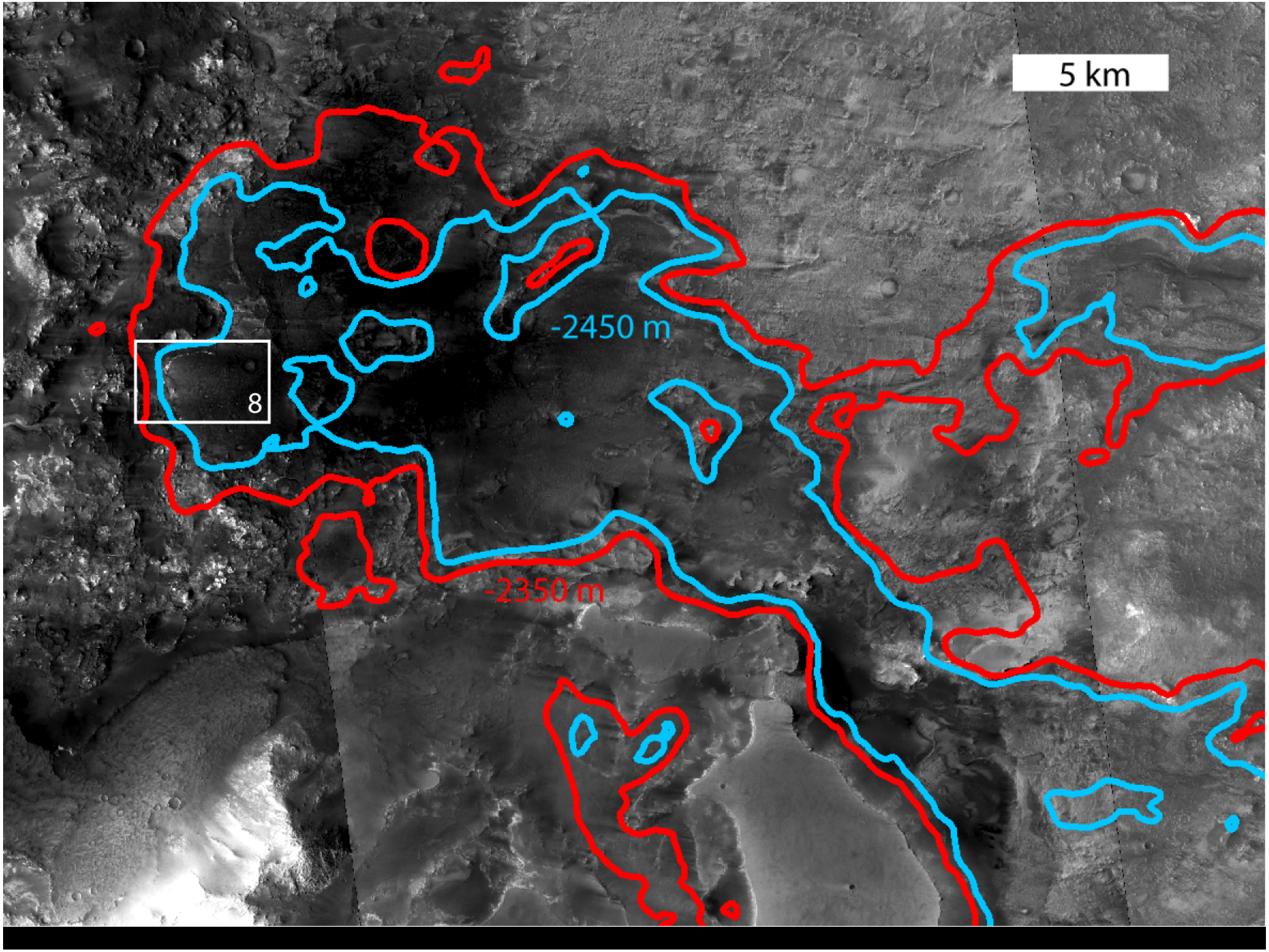

2 km
N
-400 m
-2500 m
5 km

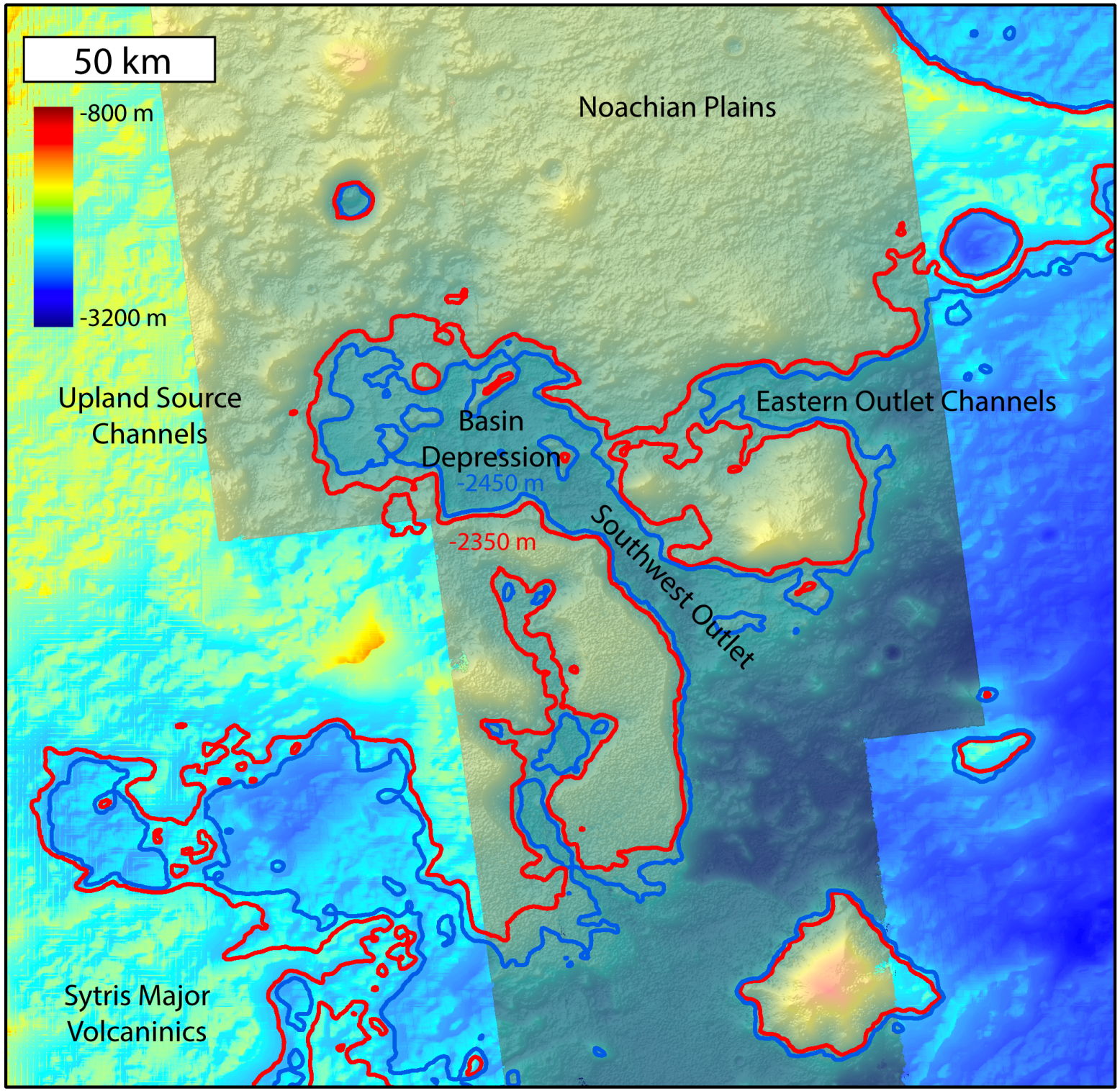

-2350 m Contuor
-2450 m
Contuor
Outlet
Channel
Channel
Fan
Potential
Outlet
Channel

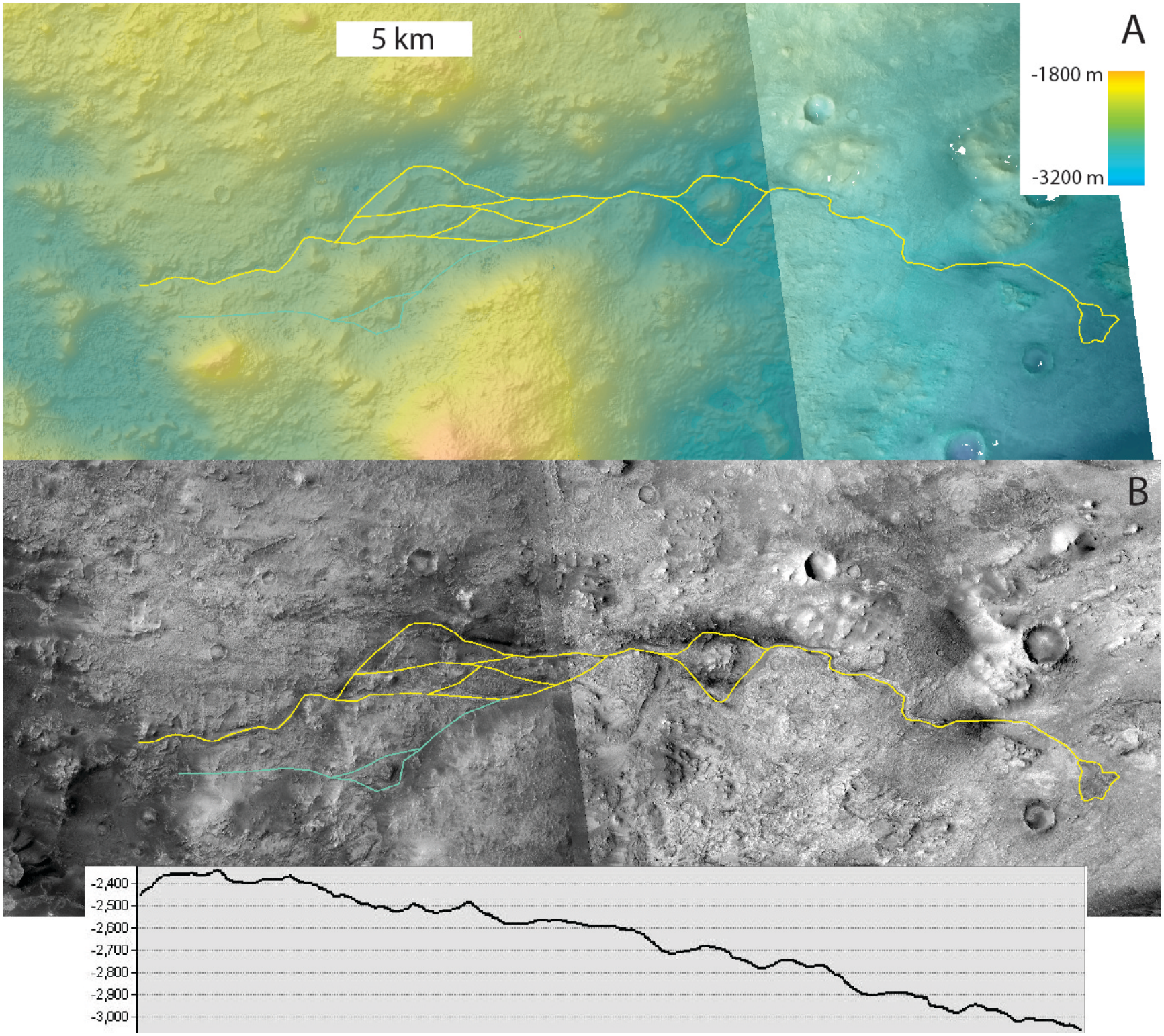

Isidis Planitia
Isidis Dorsa
Beagle 2 Lander (UK)
Syrtis Major Planum
Libya

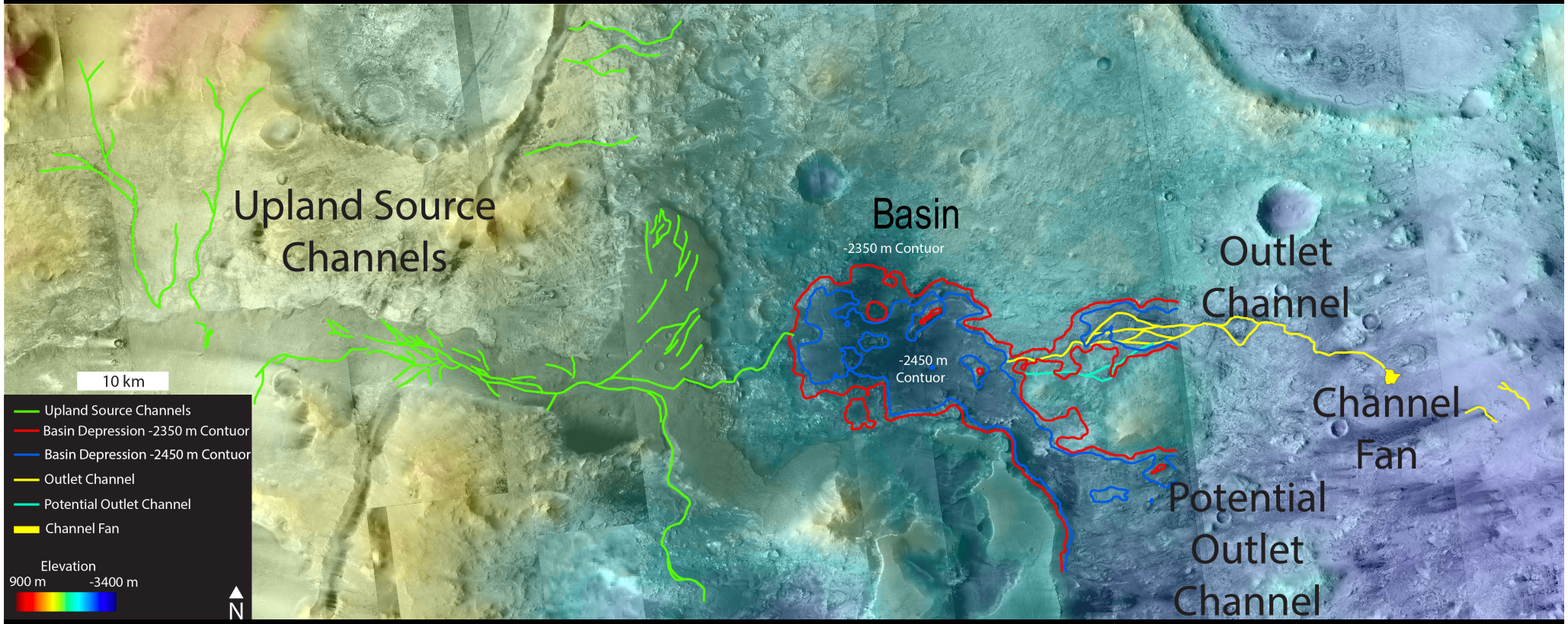

NE Syrtis
Isidis Planitia
Isidis Dorsa
Beagle 2 Lander (UK)
Syrtis Major Planum
Libya


NE Syrtis
~700 km
Syrtis Major Planum
Isidis Planitia
Isidis Dorsa
Beagle 2 Lander (UK)
Libya


5 km
-2450 m
-2350 m
8


50 km
-800 m
-3200 m
Noachian Plains
Upland Source Channels
Basin Depression
-2450 m
-2350 m
Eastern Outlet Channels
Southwest Outlet
Sytris Major Volcaninics


5 km
A
-1800 m
-3200 m
B
-2,400
-2,500
-2,600
-2,700
-2,800
-2,900
-3,000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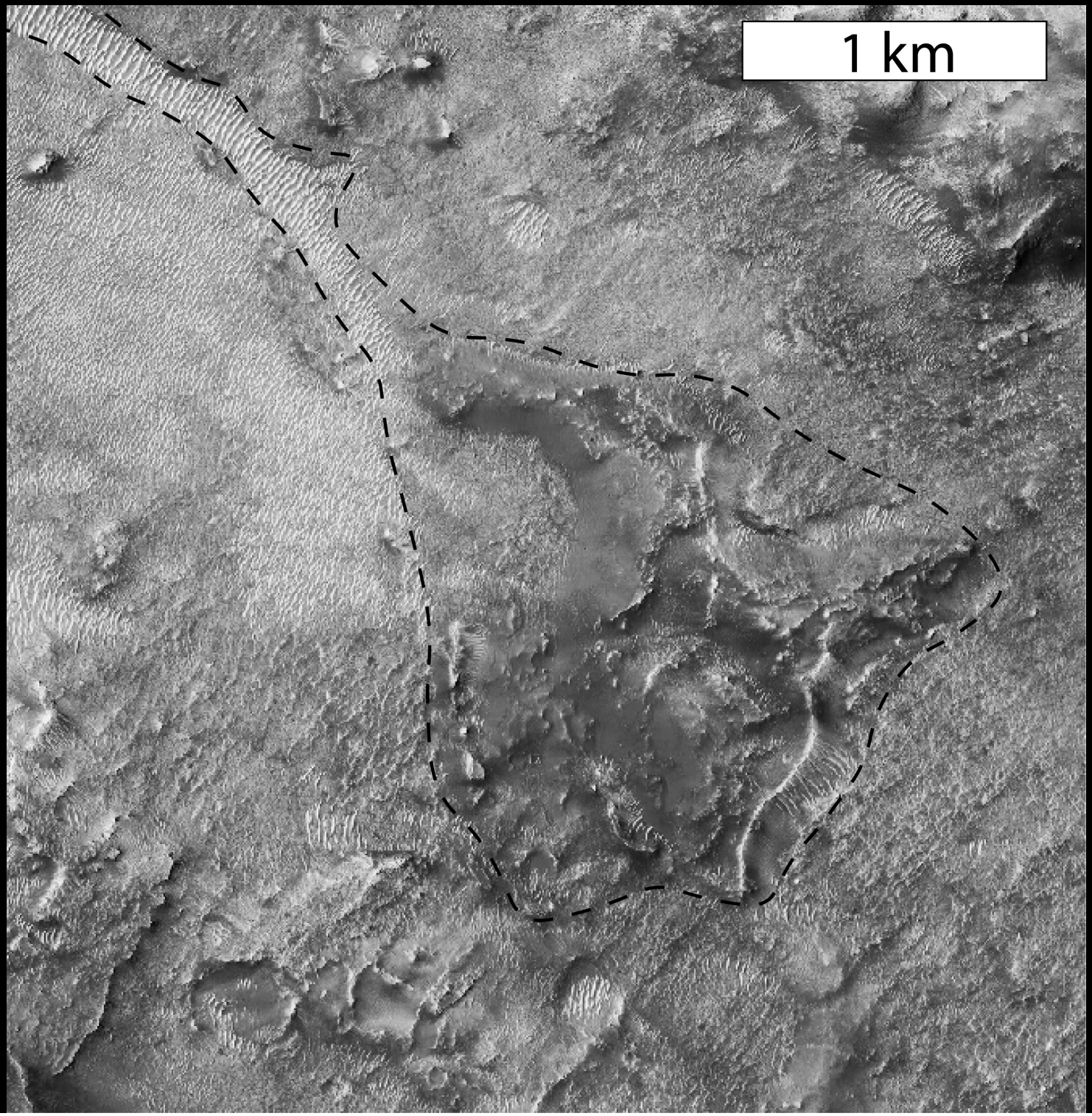
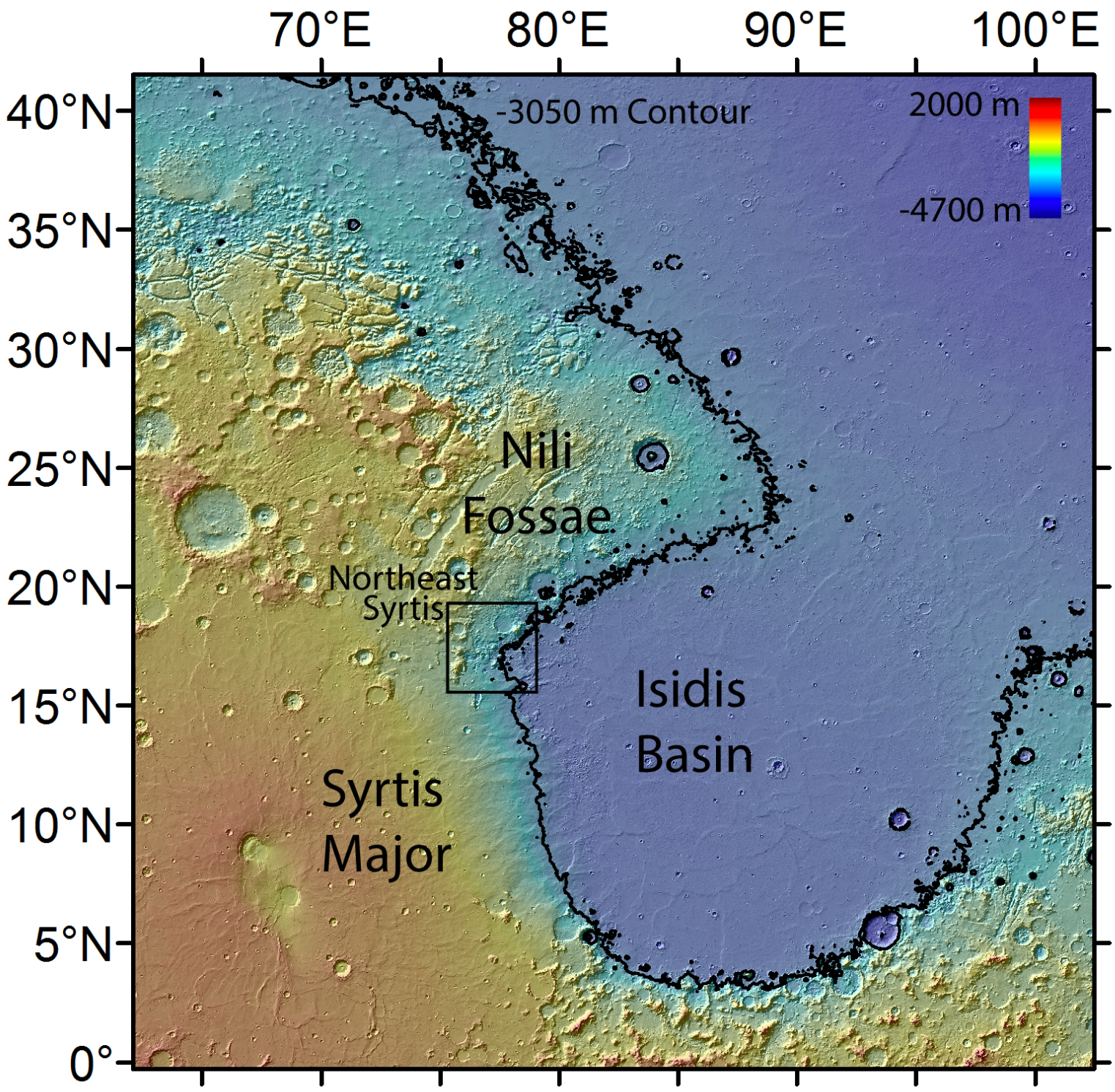
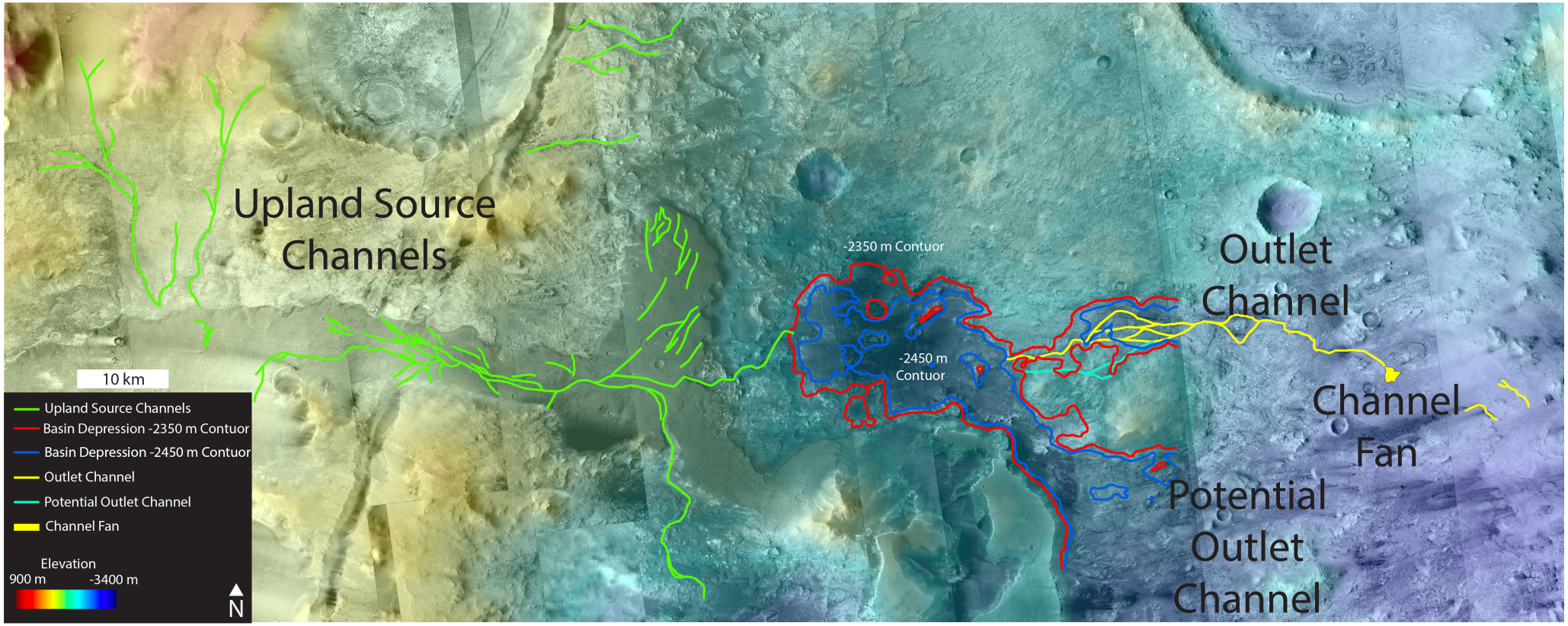
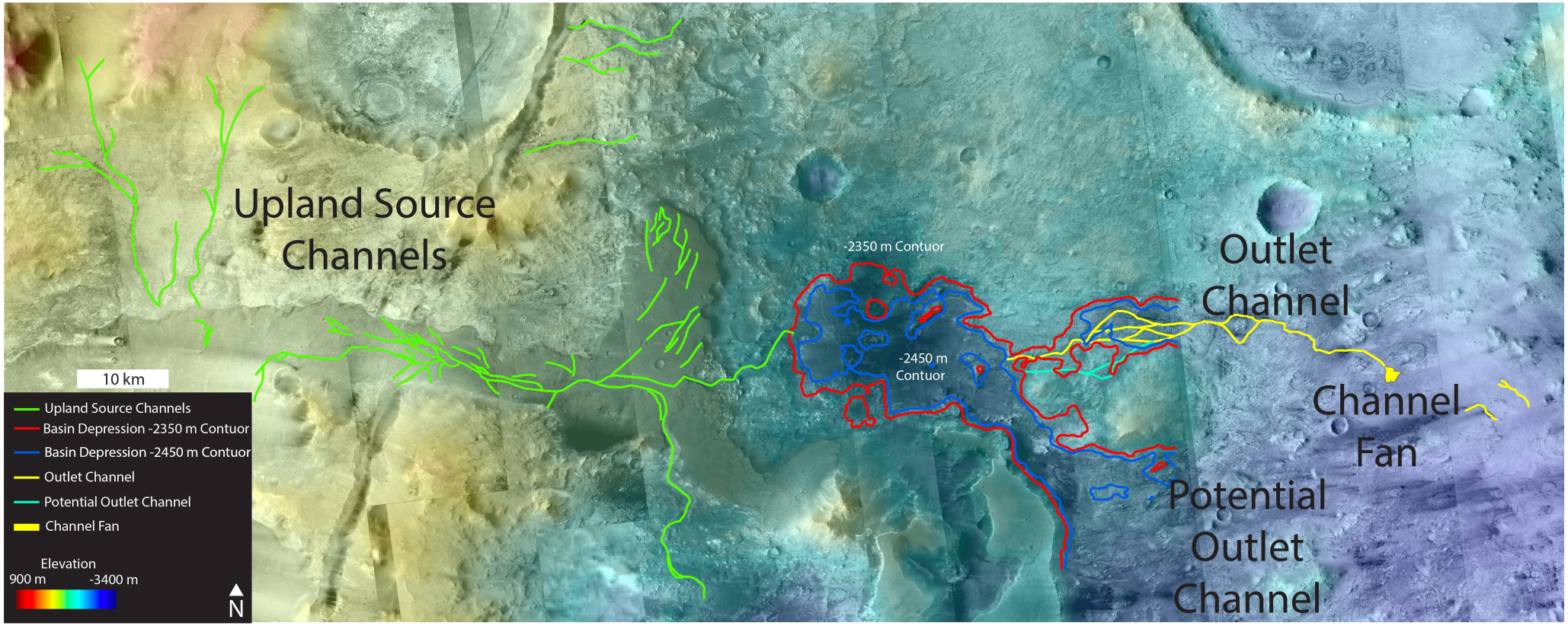
-2450 m Contuor
Outlet Channel
Channel Fan
Potential Outlet Channel
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N


1 km


70°E
80°E
90°E
100°E
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
0°
-3050 m Contour
2000 m
-4700 m
Nili
Fossae
Northeast
Syrtis
Isidis
Basin
Syrtis
Major

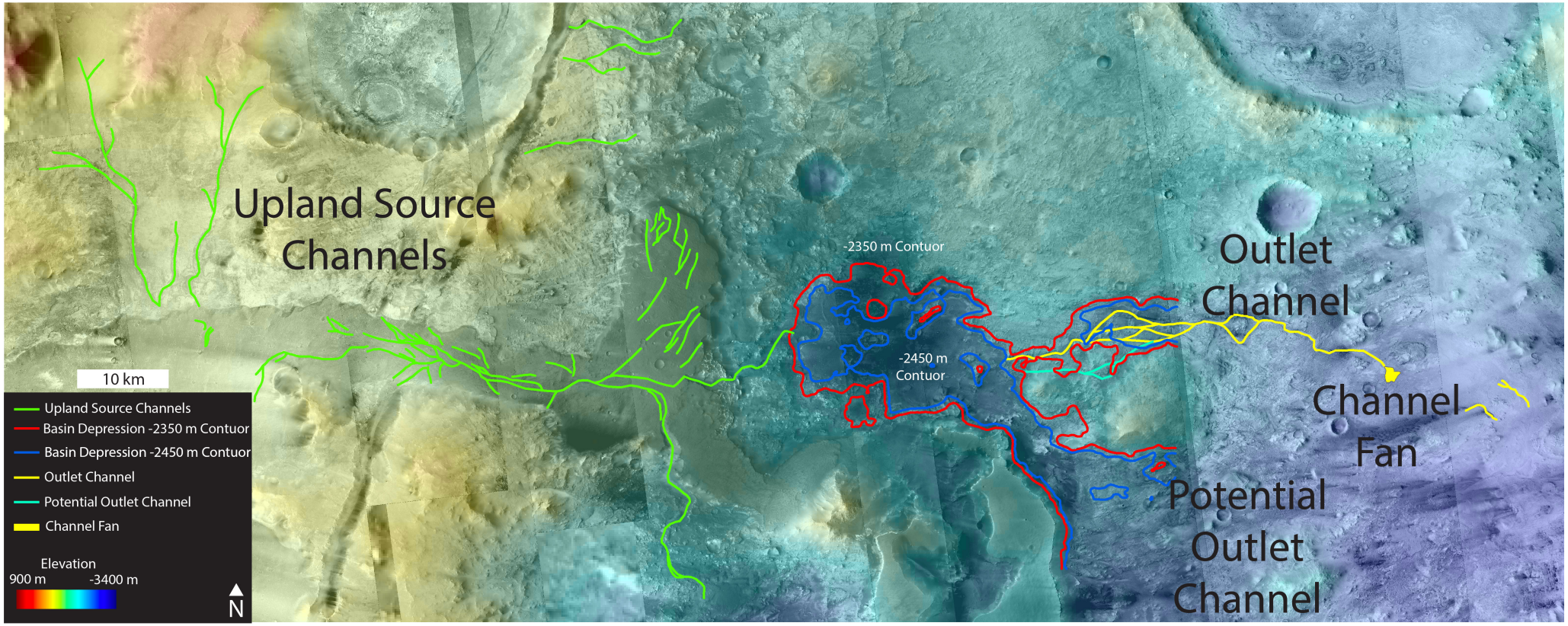


Observations:



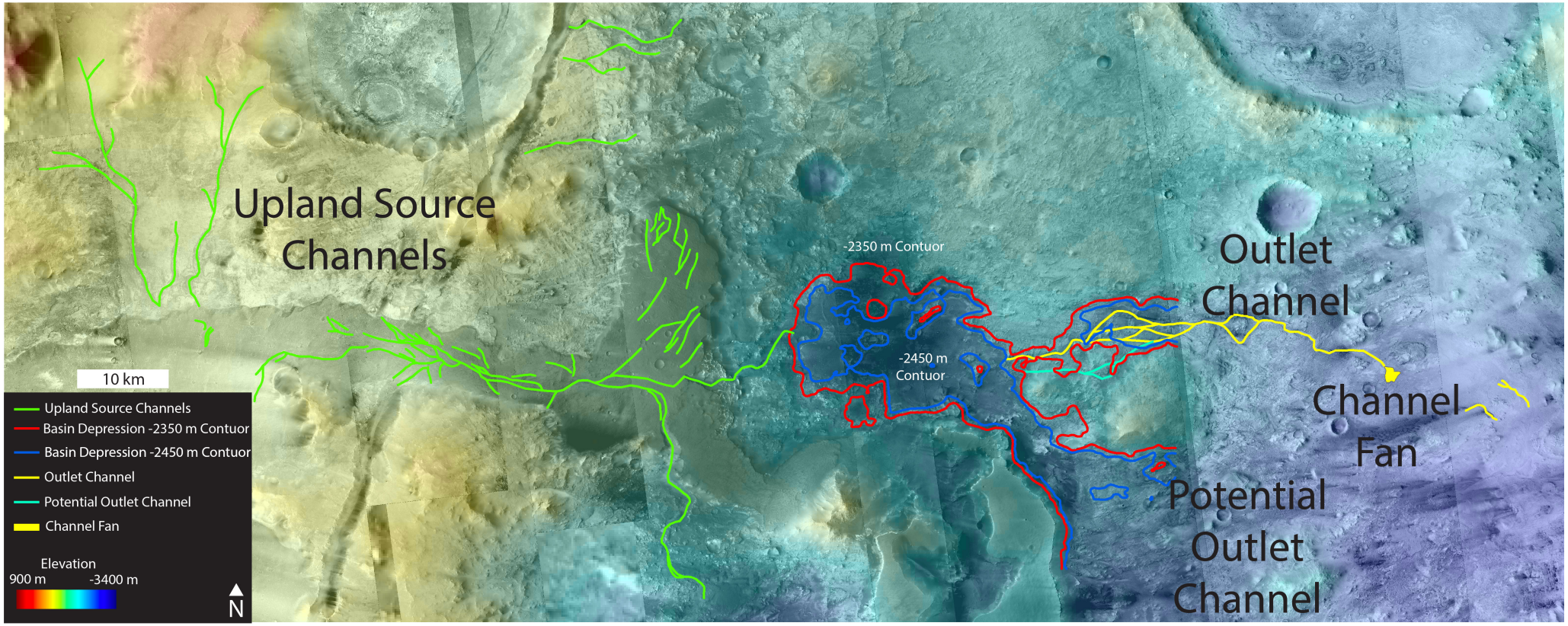
Observations:

1. Distributed sources ➡ Precipitation



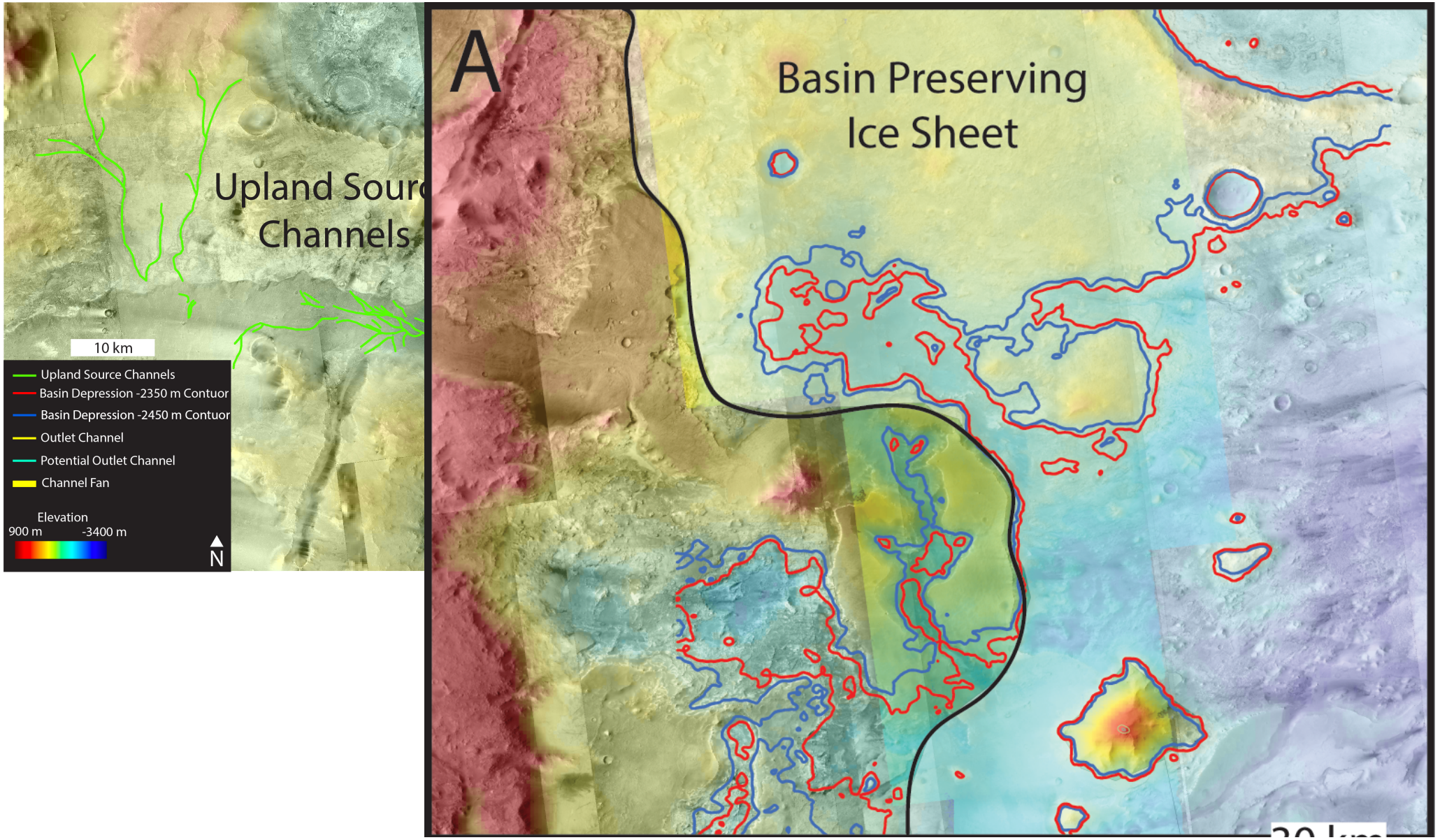
Observations:

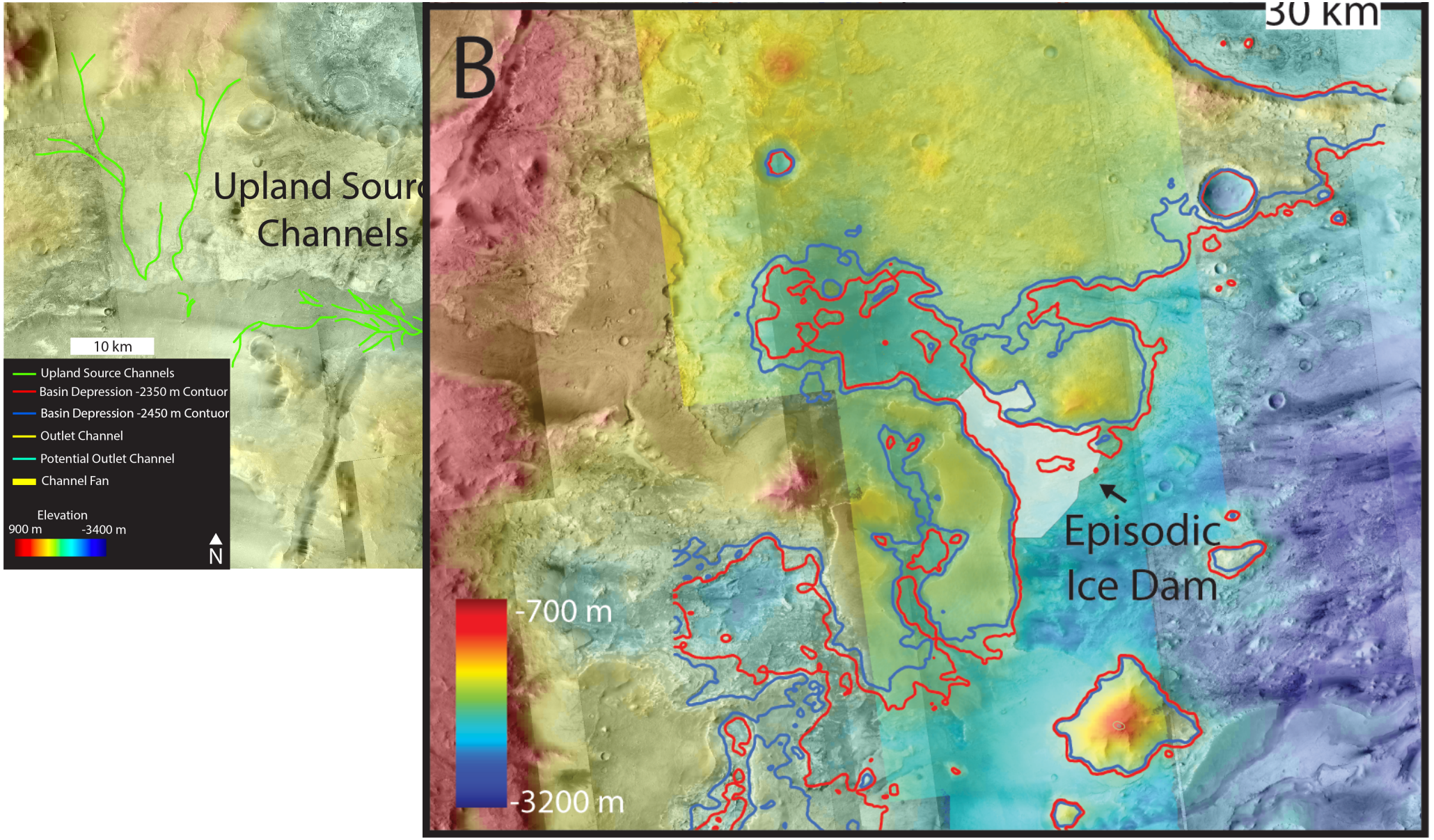
1. Distributed sources ➔ Precipitation
2. Basin's existence ➔ Ice Sheets

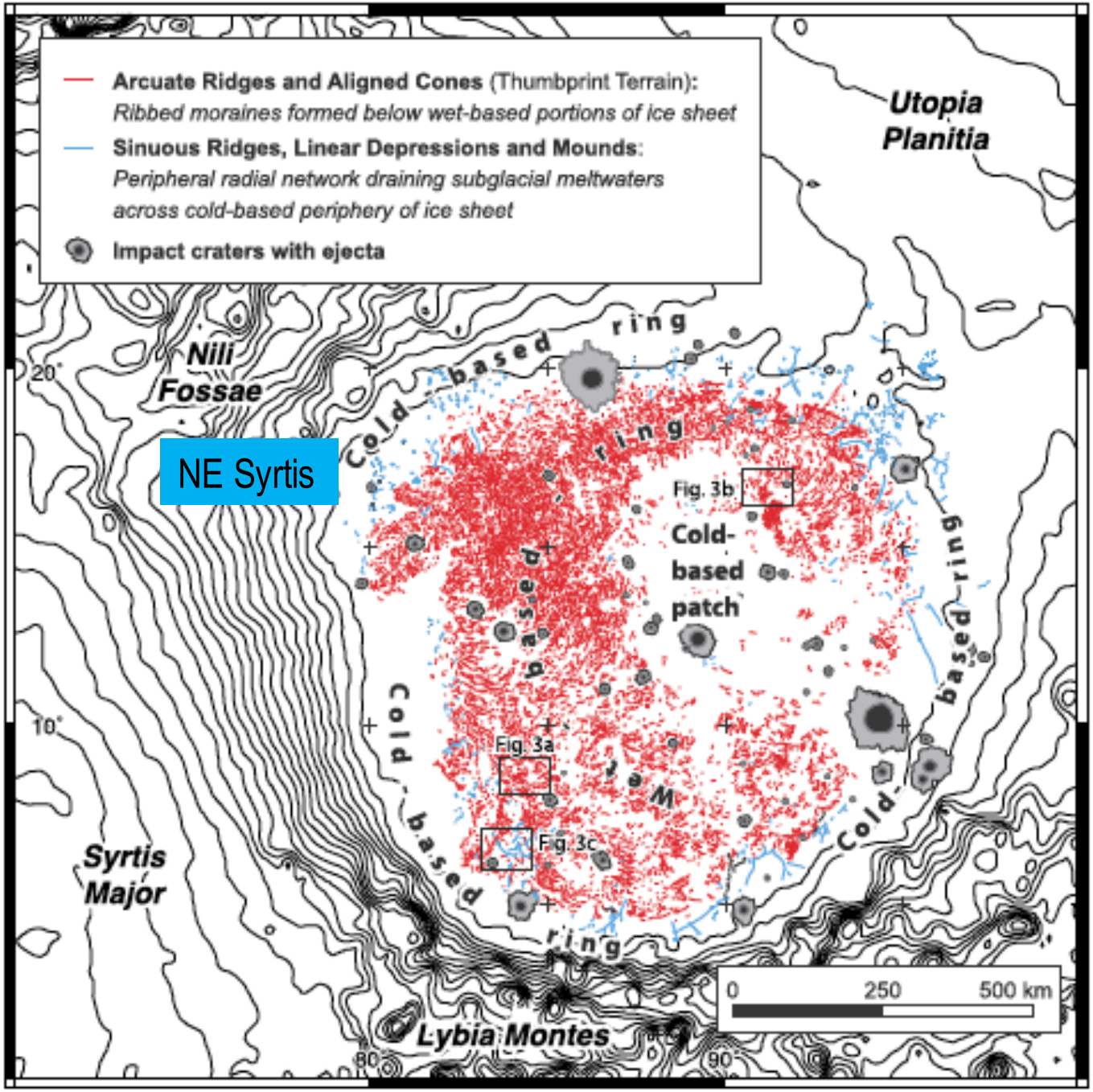


Observations:

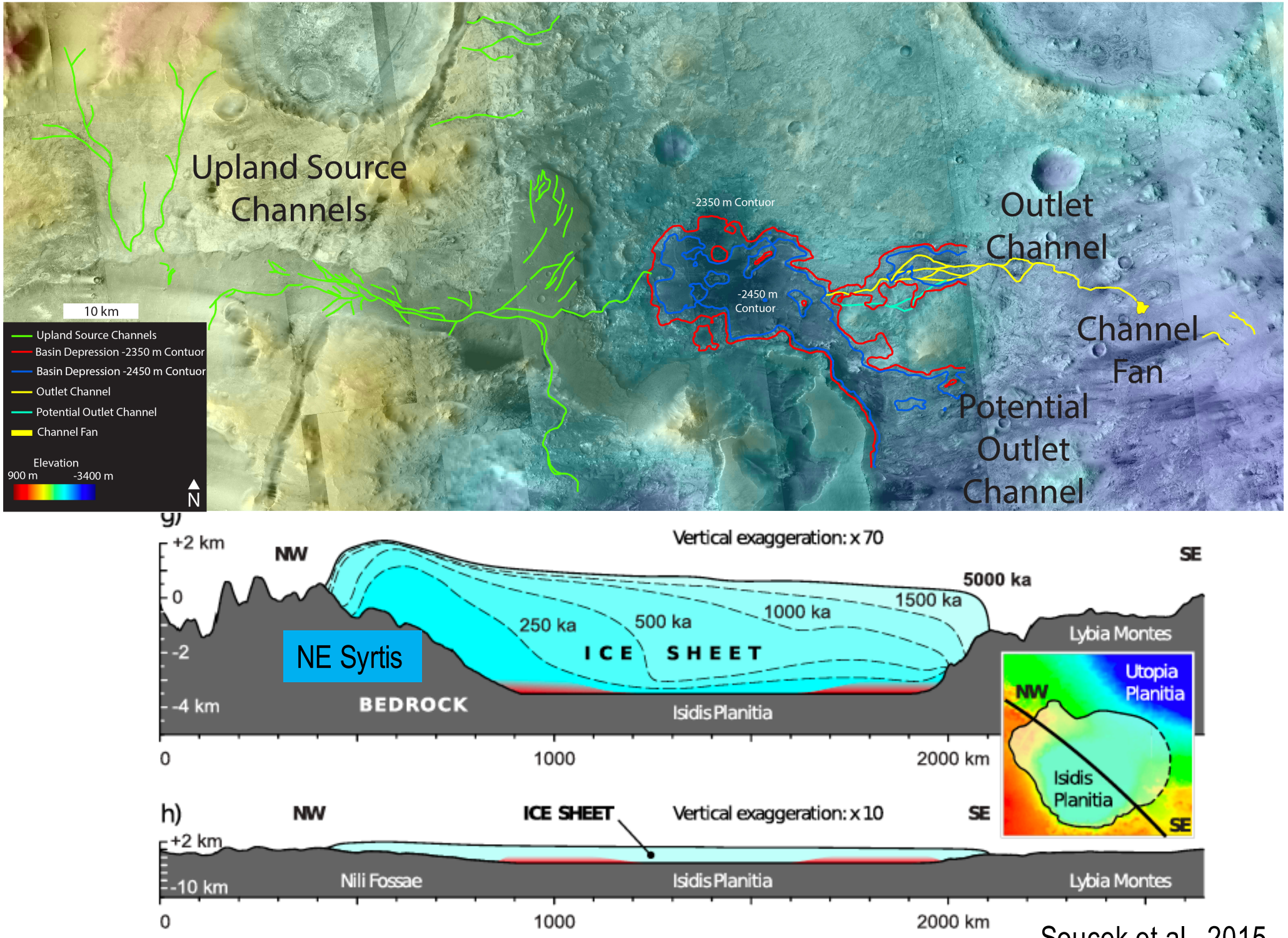
1. Distributed sources ➔ Precipitation
2. Basin's existence ➔ Ice Sheets
3. Outlet channels ➔ Episodic Ice Dams


A
Basin Preserving
Ice Sheet
Upland Sourc
Channels
10 km
Upland Source Channels
Basin Depression -2350 m Contuor
Basin Depression -2450 m Contuor
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N

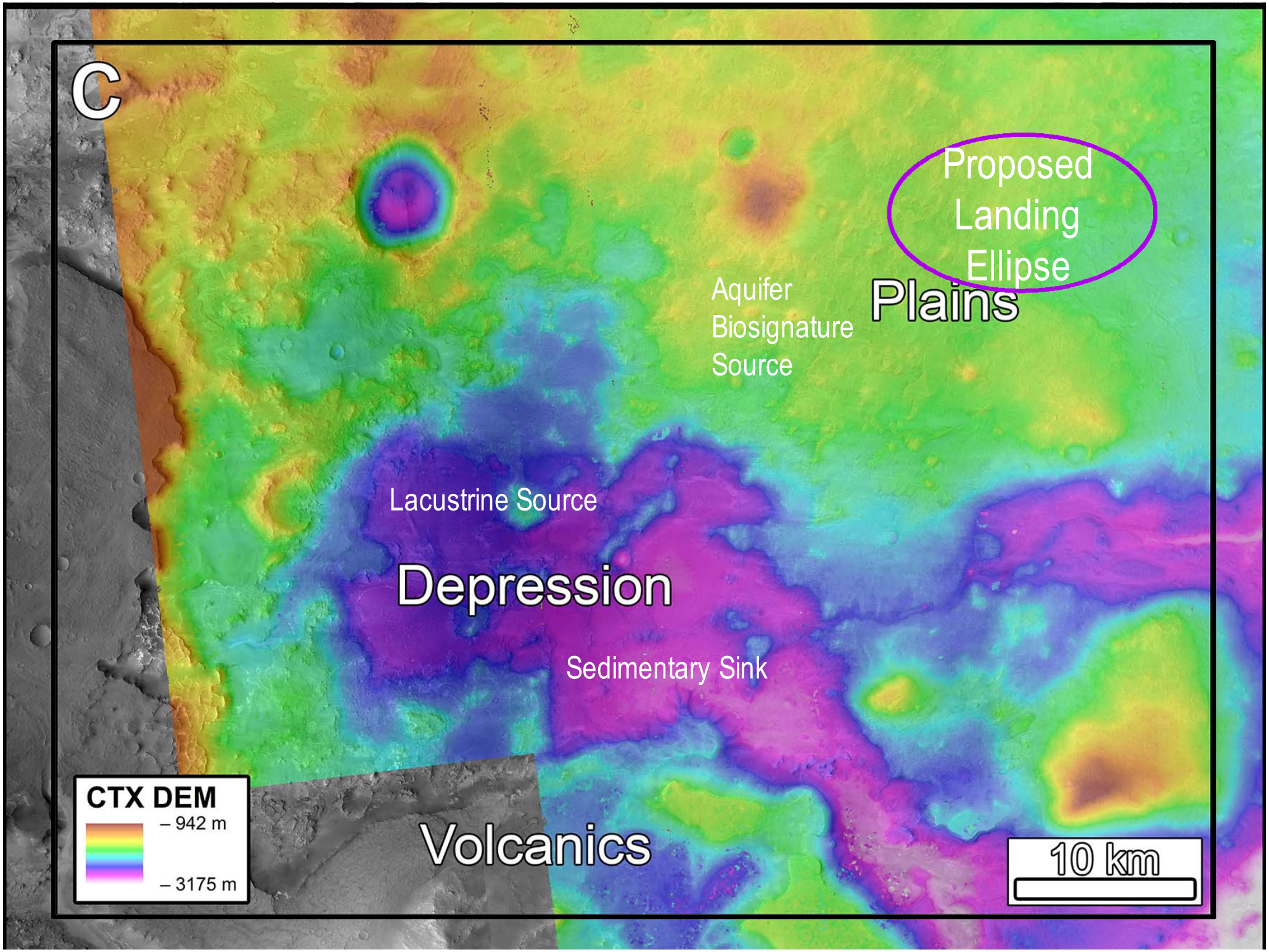

Upland Source Channels
10 km
Upland Source Channels
Basin Depression -2350 m Contour
Basin Depression -2450 m Contour
Outlet Channel
Potential Outlet Channel
Channel Fan
Elevation
900 m
-3400 m
N
B
30 km
-700 m
-3200 m
Episodic Ice Dam



Soucek et al., 2015



Soucek et al., 2015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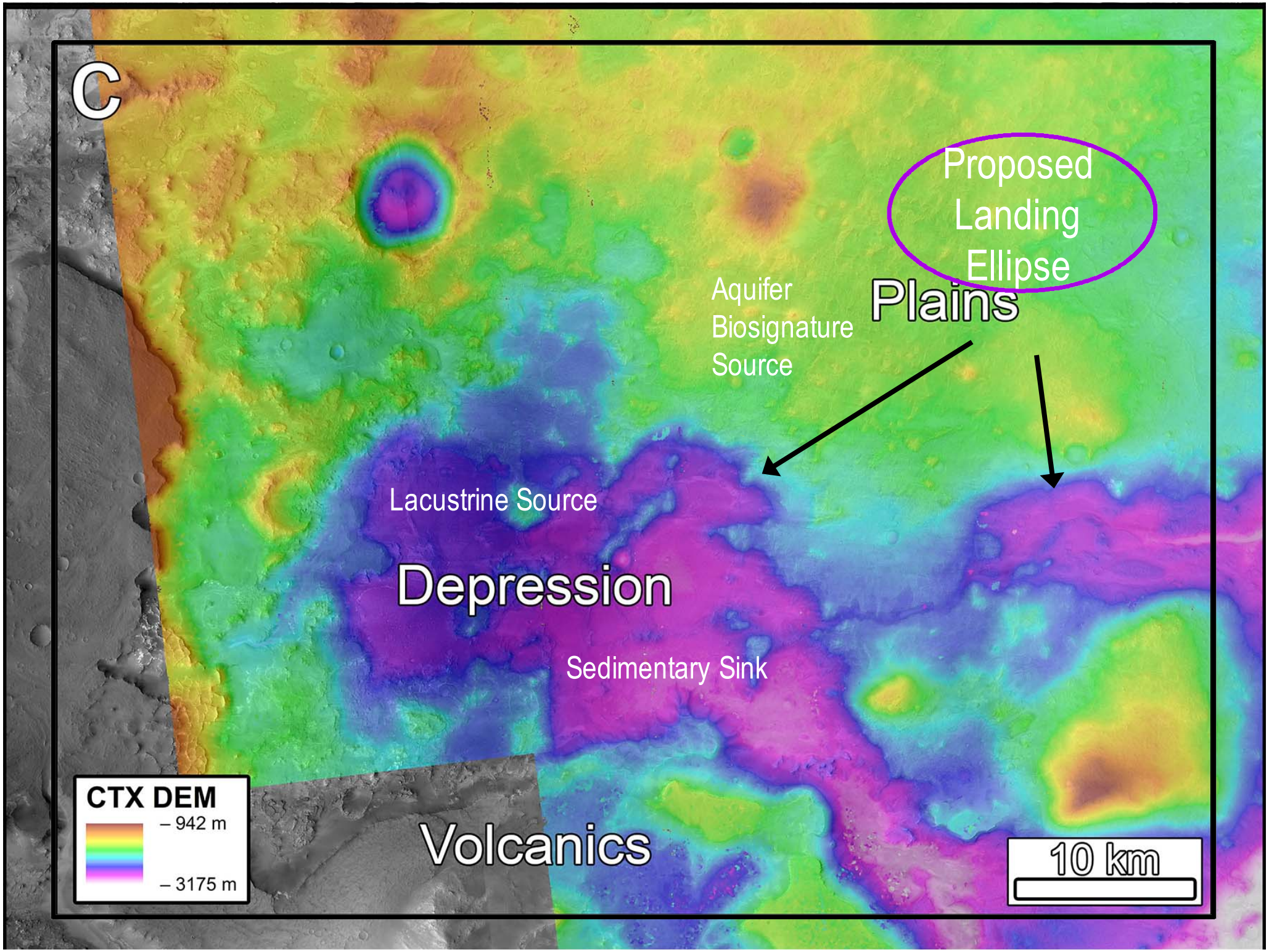
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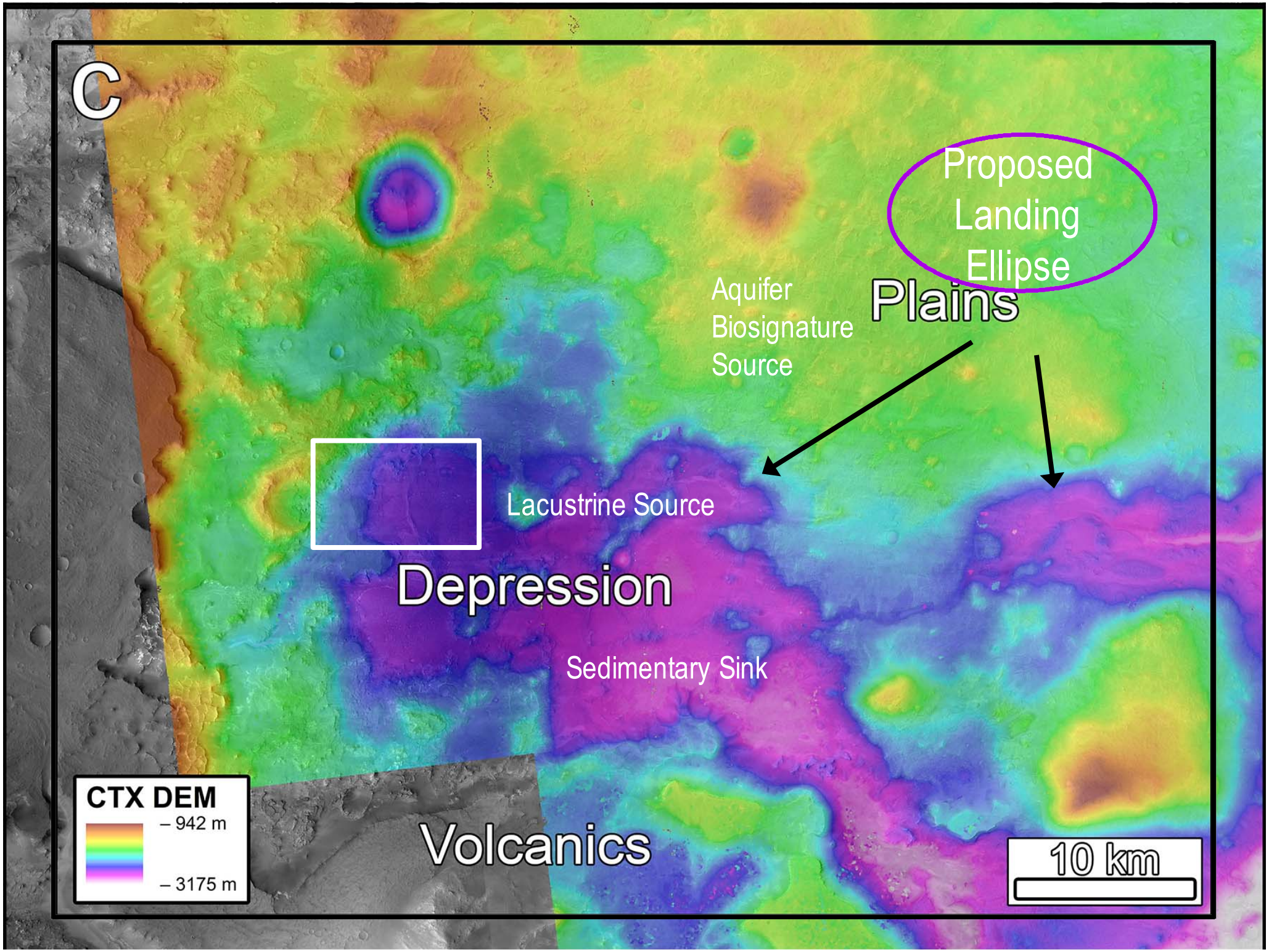
Volcanics
10 km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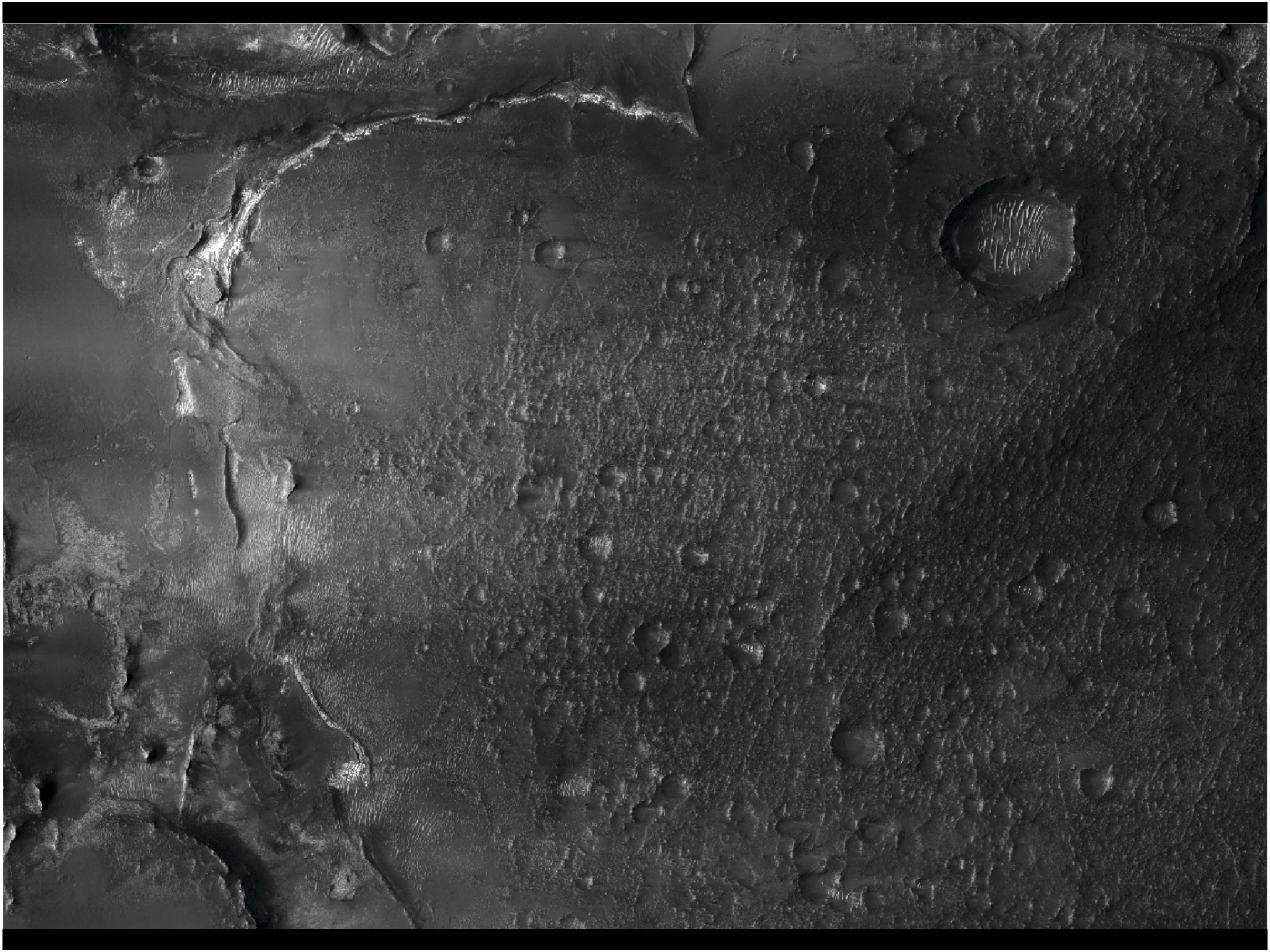
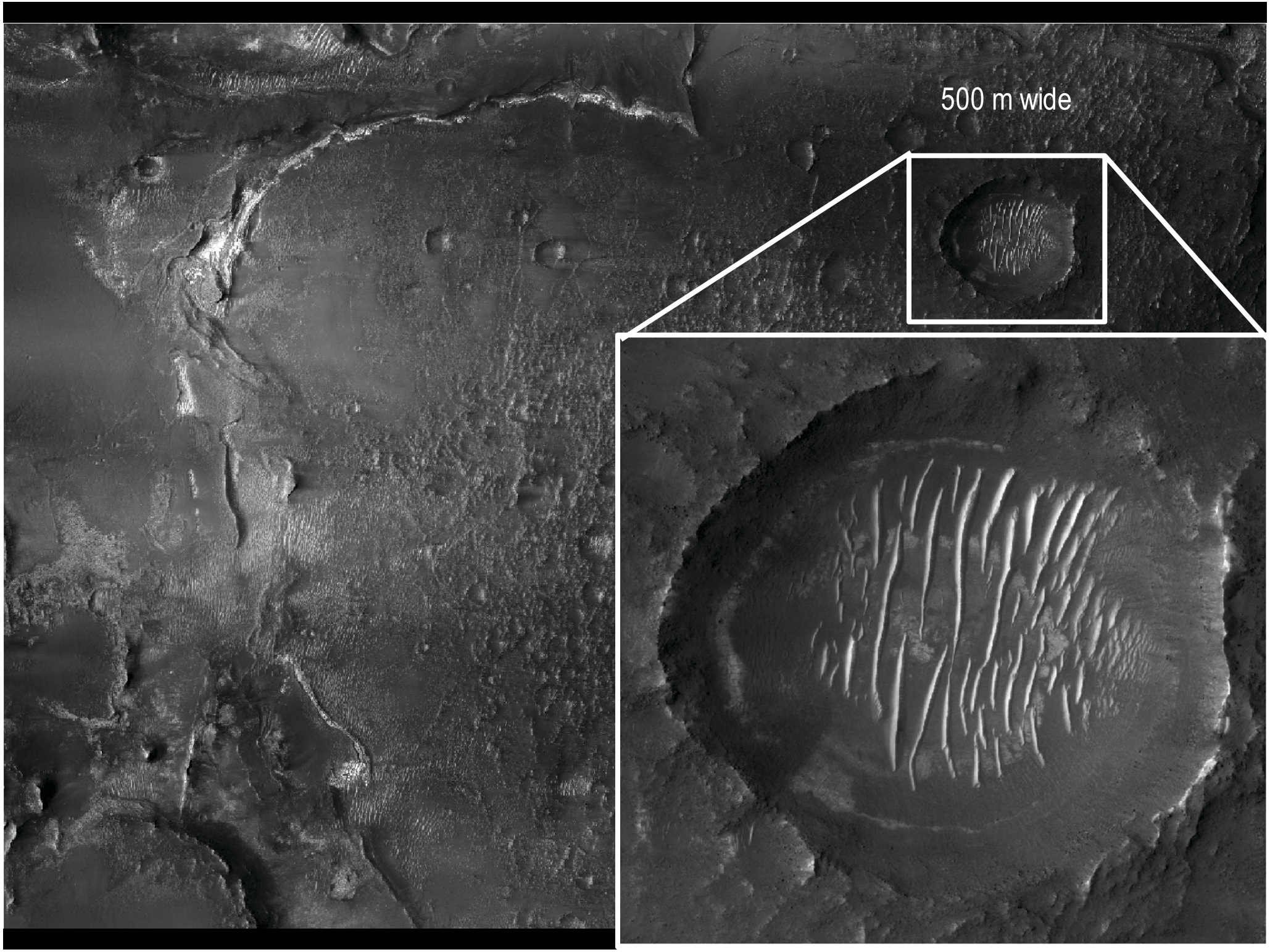
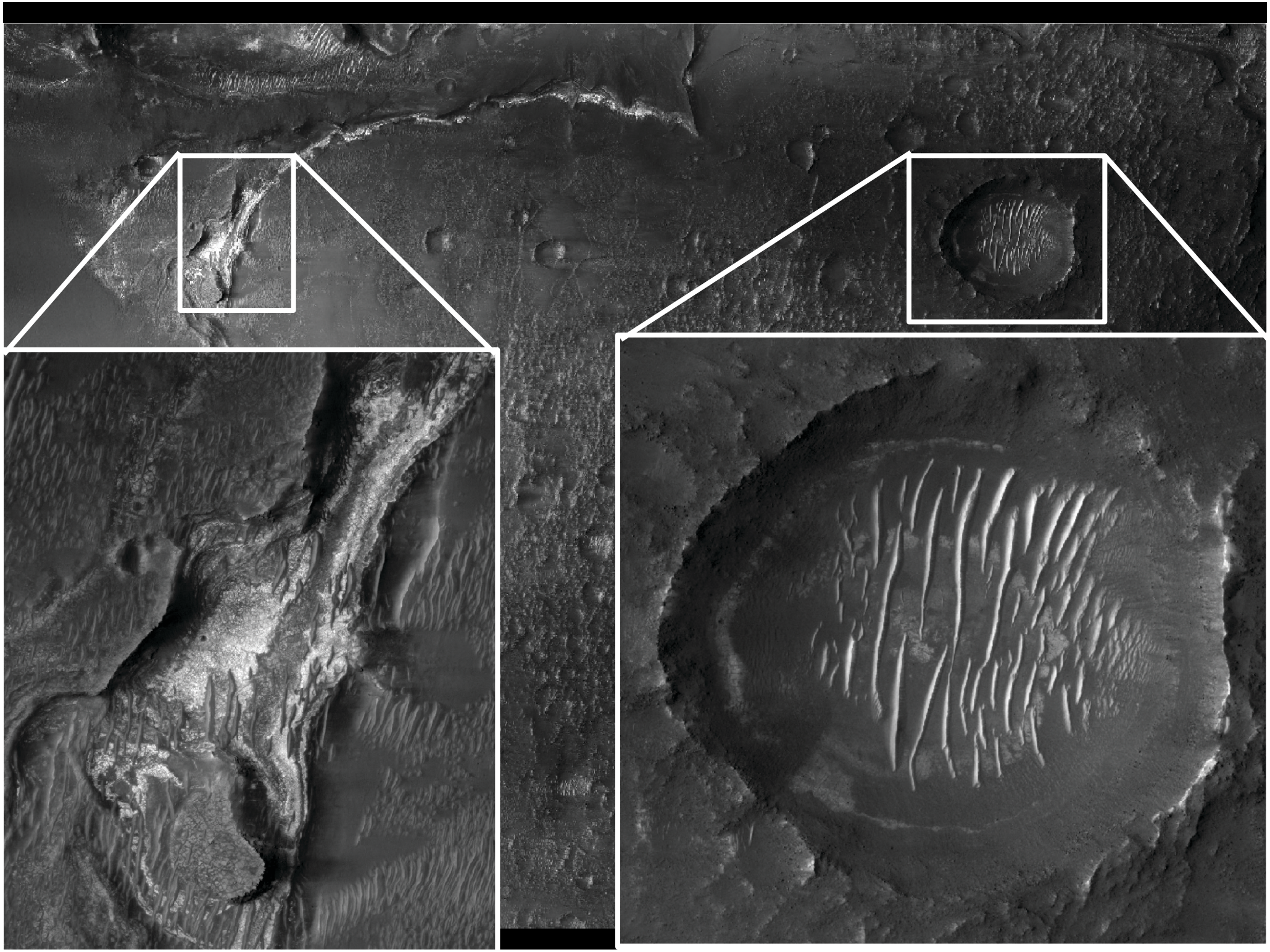
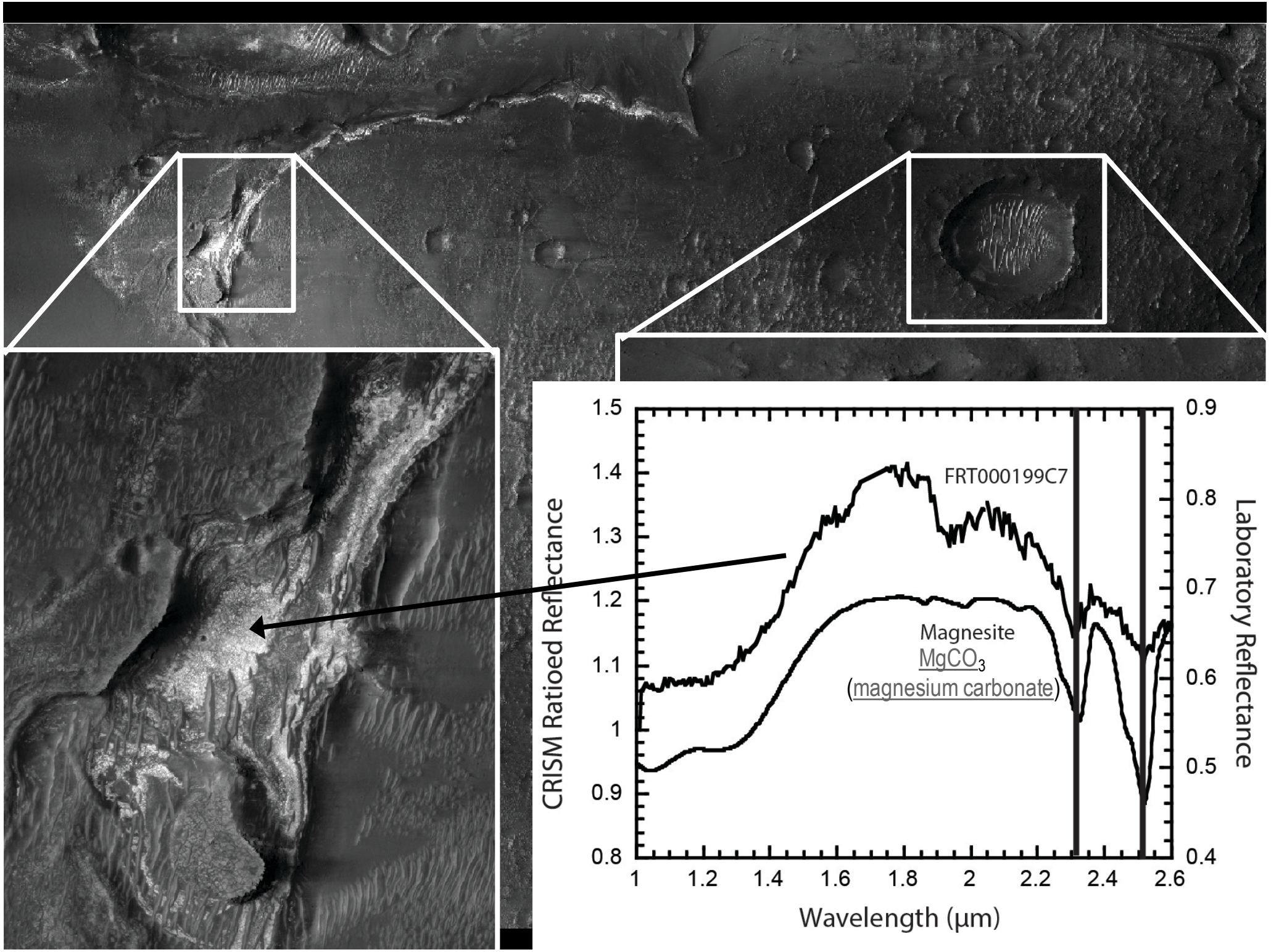
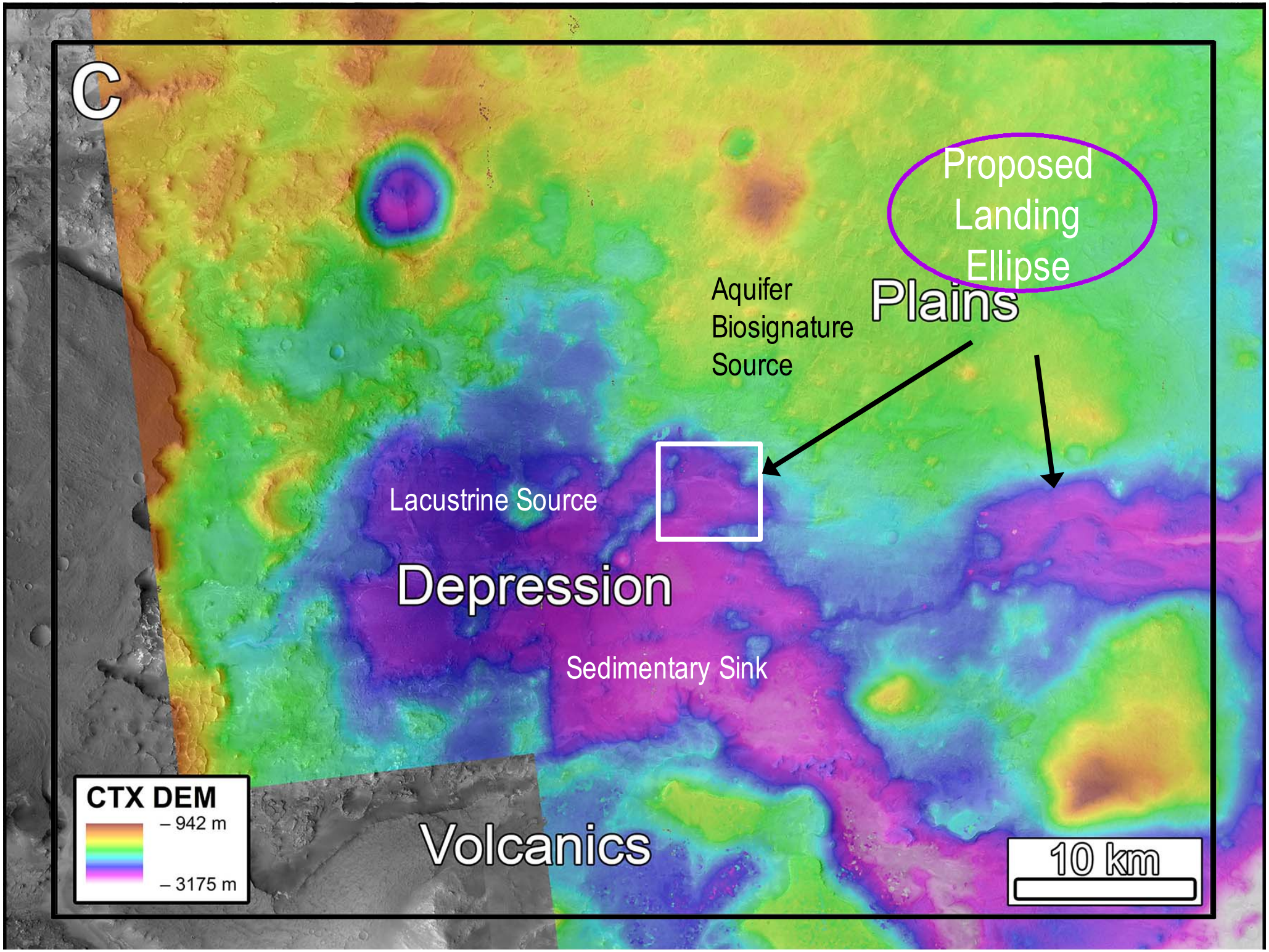
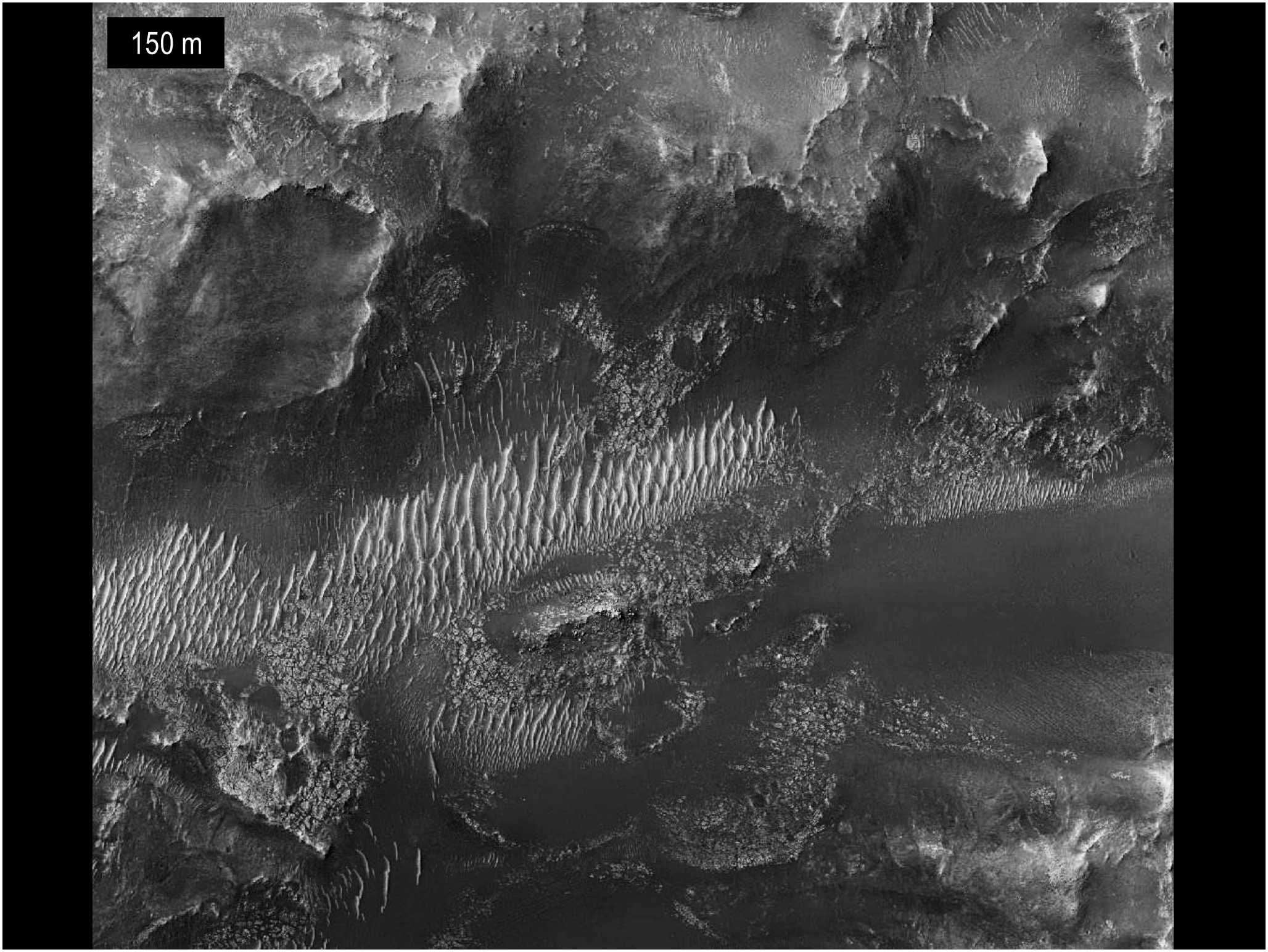


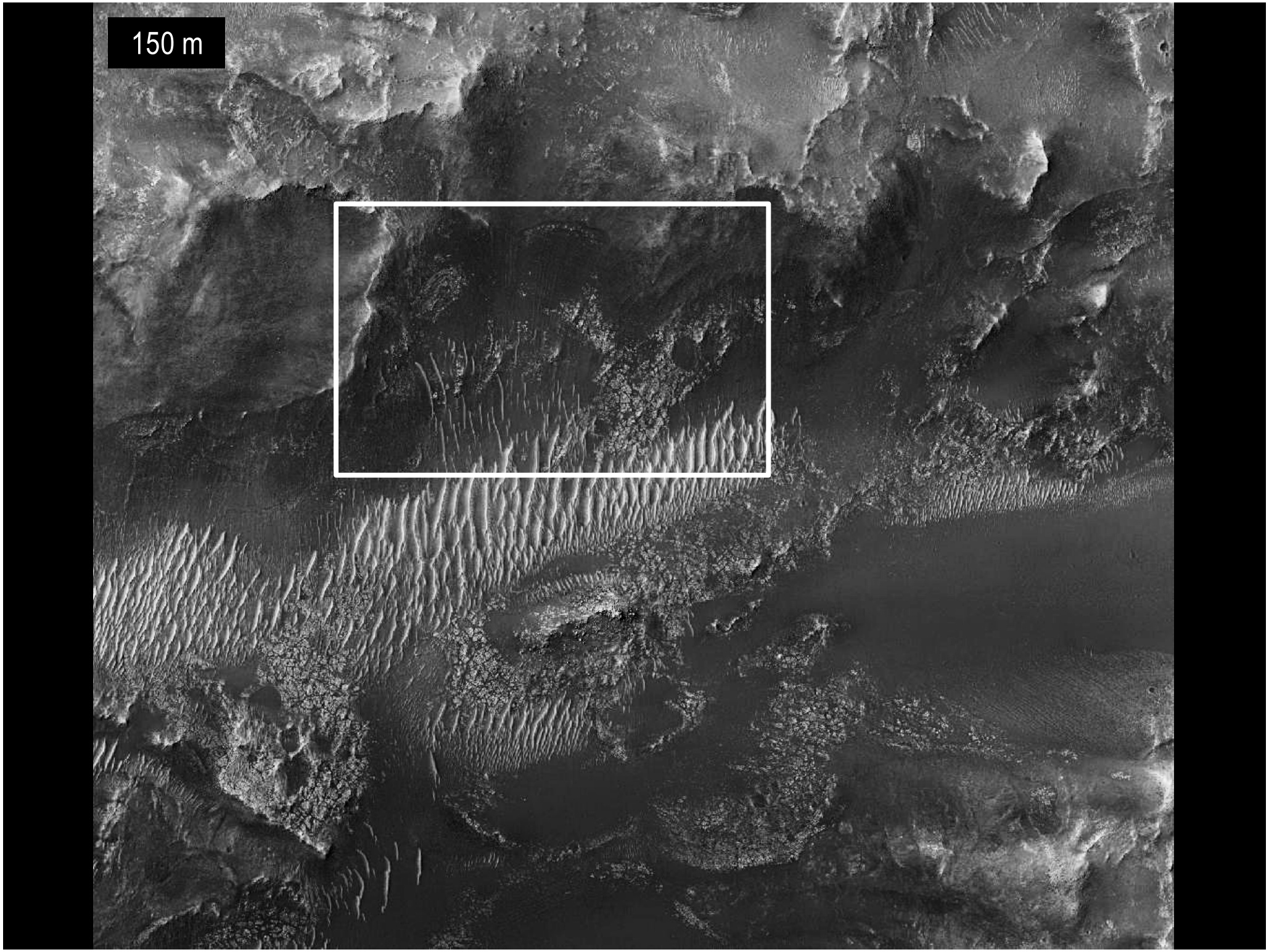

500 m wide

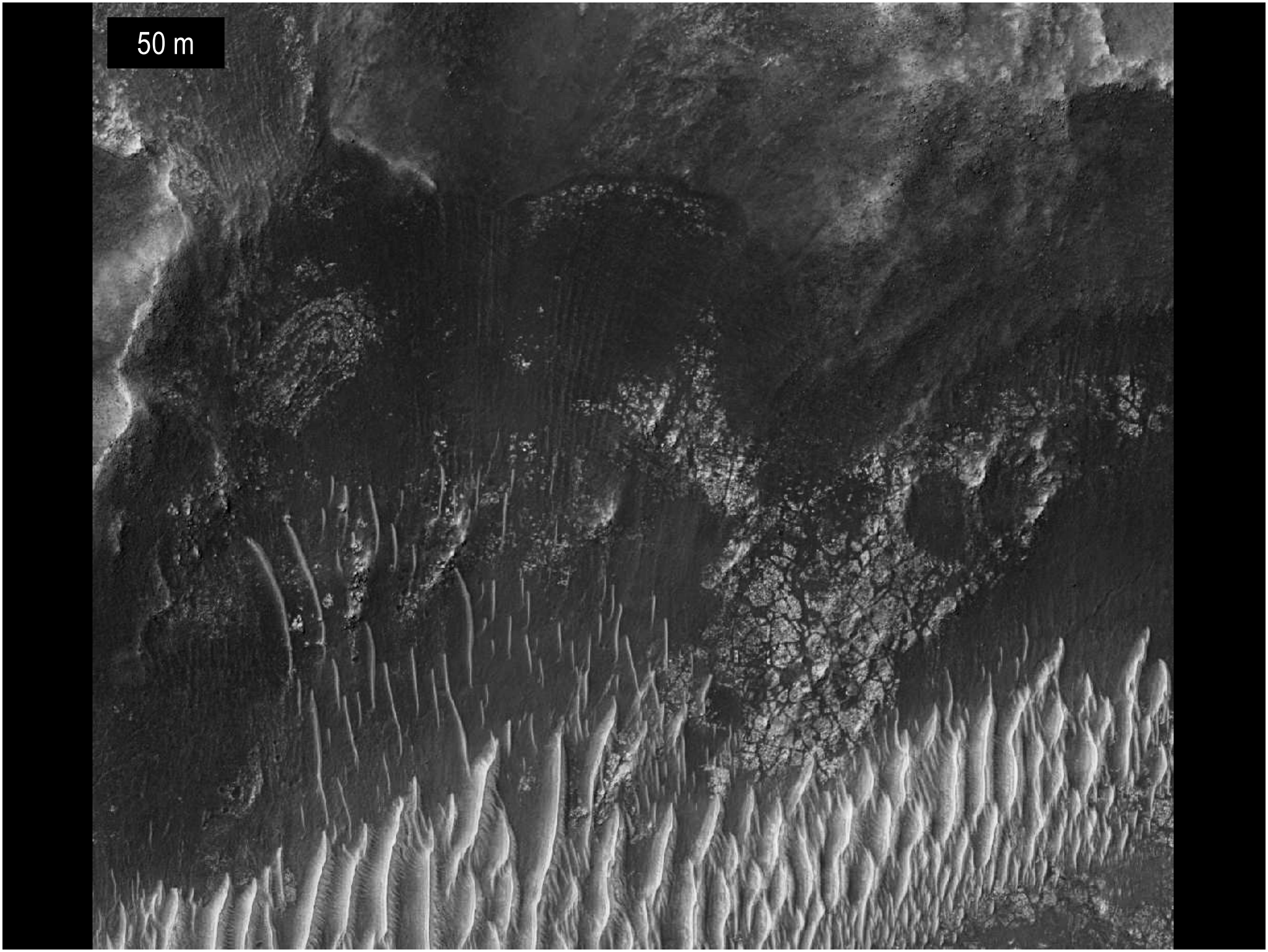


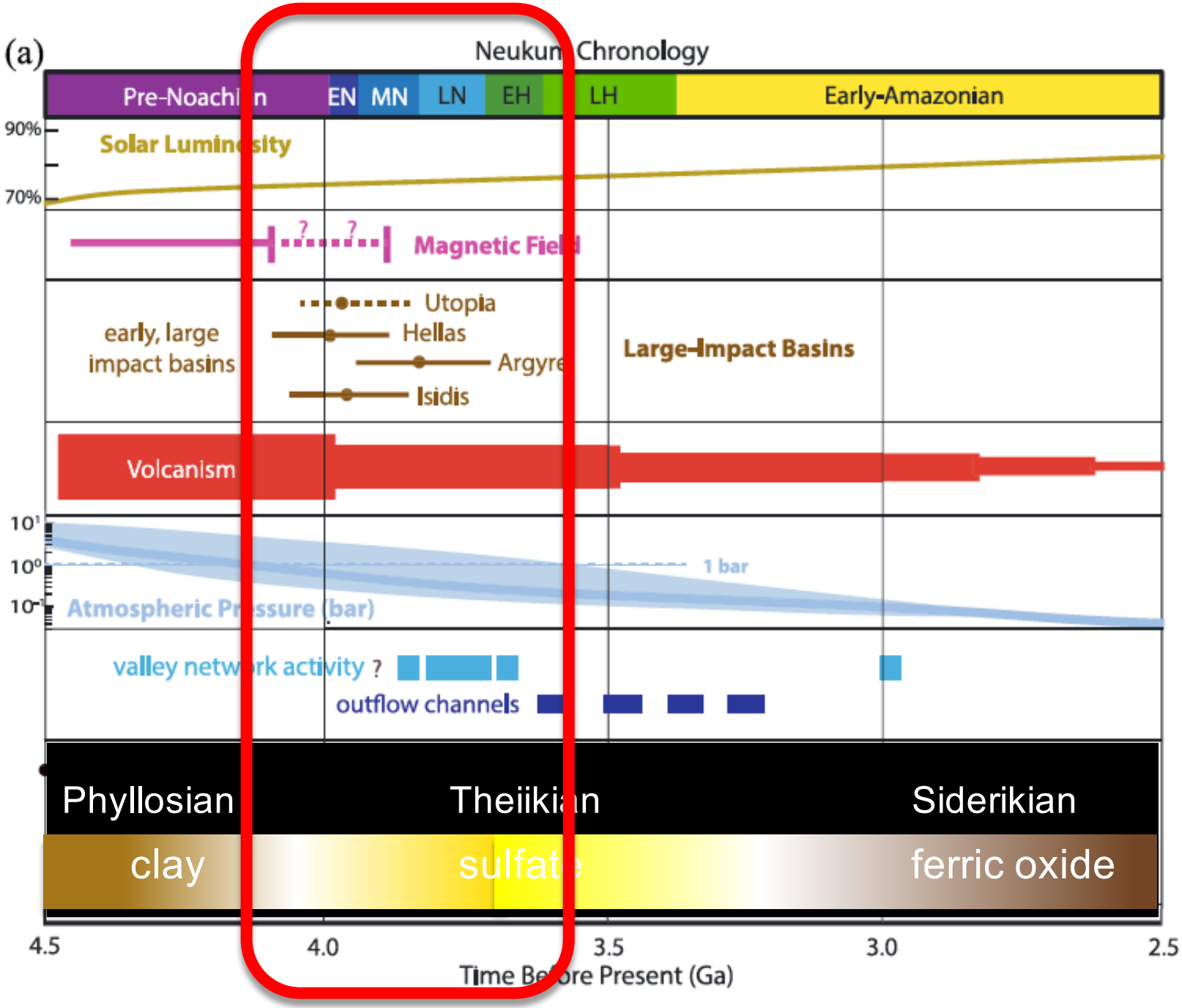

FRT000199C7
Magnesite
MgCO3
(magnesium carbonate)
CRISM Ratioed Reflectance
Laboratory Reflectance
Wavelength (μm)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.9
0.8
0.7
0.6
0.5
0.4
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6

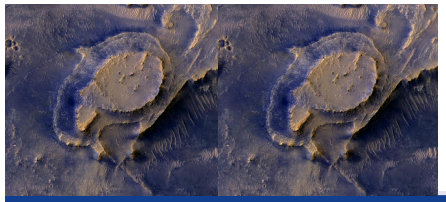

C
Proposed
Landing
Ellipse
Aquifer
Biosignature
Source
Plains
Lacustrine Source
Depression
Sedimentary Sink
CTX DEM
– 942 m
– 3175 m
Volcanics
10 km


150 m

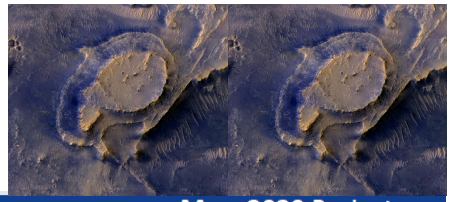

150 m


50 m


(a)
Neukum Chronology
Pre-Noachian
EN
MN
LN
EH
LH
Early-Amazonian
90%
70%
Solar Luminosity
Magnetic Field
Utopia
Hellas
Argyre
Isidis
early, large impact basins
Large-Impact Basins
Volcanism
1 bar
Atmospheric Pressure (bar)
valley network activity ?
outflow channels
Phyllosian
Theiikian
Siderikian
clay
sulfate
ferric oxide
4.5
4.0
3.5
3.0
2.5
Time Before Present (Ga)

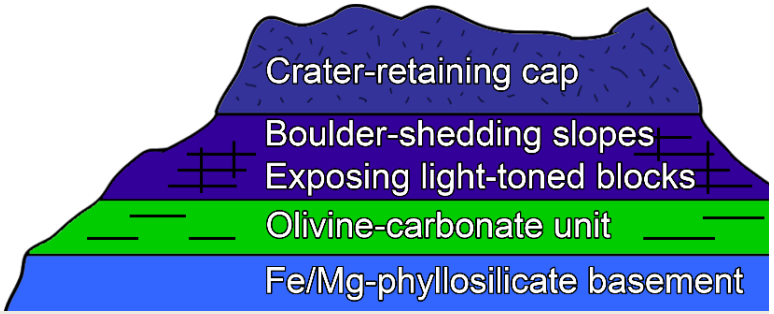


Northeastern Syrtis Major Mesas



Mars 2020 Project

Northeast Syrtis Major Mesas are <u>**spatially concentrated time capsules**</u> that record critical events in **the Pre-Noachian, Noachian and Hesperian.**



Characterize geologic history of astrobiologically relevant site/units

- **3 distinct, time-ordered formations** (mafic cap, carbonate, basement); one with **3 subunits** (megabreccia basement, massive basement, Al-phyllosilicate weathering horizon) are **mappable from orbit for easy rover direction**
- **~250 Myr Noachian to Hesperian historical** record is the earliest accessible and well-understood in the context of Mars history, bounded by the Isidis impact event and Syrtis Major volcanism (with still older megabreccia)

Assess habitability/past life in units with high biosignature preservation potential

- **Regionally extensive carbonates** represent either **near-subsurface mineralization** of host rock or **travertine-like mineral springs precipitation** – either has **high biosignature preservation potential**
- The **Noachian clay basement** and **breccia blocks preserve rocks** from when **Mars had a magnetic field** and thicker atmosphere**.** Cross-crossing veins point to **available water** in a **continuously habitable environment** – the NE Syrtis paleo-aquifer is a good place to search for mineralized life

Cache scientifically compelling samples

- **4 aqueous environments** (early clays, early carbonates, weathering horizons, *go-to sulfate sediments*) have distinct astrobio. potential, record of atm. evolution, volatile sequestration for traditional, clumped isotopes
- **4 age-date bins** for Martian chronology **(1)** Isidis-formed melt within Noachian basement, **(2)** regional olivine-rich unit, **(3)** dark-toned mafic cap rock, ***(4)*** *Syrtis lava front (go-to)*
- **3** lithologies record **Igneous** evolutionary history from **Pre-Noachian** to **Early Hesperian**, with distinct low-Ca pyroxene, olivine enriched (komatiite-type hot lava or mantle xenolith), high-Ca pyroxene lavas